Instruction Manual for

Model 7000

Digital Multimeter

APRIL 1967

Instrumentation

Preliminary

Instruction Manual for

Model 7000

Serial Number

Digital Multimeter

FAIRCHILD
INSTRUMENTATION

475 Ellis Street, Mtn. View, Calif. 94040
Phone (415) 962-2011 / TWX: 910-379-6944

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FAIRCHILD INSTRUMENTATION
EQUIPMENT WARRANTY

Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

The liability of Seller under this warranty is limited, at Seller's option, solely to repair, replacement with equivalent Fairchild equipment, or an appropriate credit adjustment not to exceed the original equipment sales price, of equipment returned to the Seller provided that:

a. Seller is promptly notified in writing by Buyer upon discovery of defects,

b. The defective equipment is returned to Seller, transportation charges prepaid by Buyer, and,

c. Seller's examination of such equipment discloses to its satisfaction that defects were not caused by negligence, misuse, improper installation, accident, or unauthorized repair or alteration by the Buyer.

This warranty does not include mechanical parts failing from normal usage nor does it cover limited life electrical components which deteriorate with age such as vacuum tubes, chopper, lamps, etc. In the case of accessories, i.e., card punches, typewriters, etc., not manufactured by the Seller, but which are furnished with the Seller's equipment, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer.

This warranty is applicable to the original Buyer only and constitutes the sole and exclusive warranty of Seller. No other warranty is made, expressed or implied.

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This manual provides operating and maintenance information for the Fairchild Model 7000 Digital Multimeter. Section I is a general description of the Model 7000, with a detailed list of options. Sections II and III contain installation and operating information. The theory of operation is described in section IV. Section V outlines maintenance and troubleshooting procedures, and includes schematic diagrams for the instrument. Section VI has tables of replaceable parts and recommended spares.

1-3. GENERAL DESCRIPTION

1-4. The Model 7000 Digital Multimeter employs the dual slope integrating measurement technique to provide an instrument with excellent accuracy and long term stability characteristics. Solid state construction with maximum use of integrated circuits gives this instrument outstanding performance in a compact package.

1-5. The basic instrument is offered as a dc voltmeter. However, options (in the form of plug-in boards) extend the measurement capability to ac volts, dc current, and ohms measurements. In addition, autorange and BCD output coding plug-in boards are available. Measurement function is selected with the front panel FUNCTION switch. Visual indicators located on the right side of the readout panel show each function selected. Dc voltage measurements are given in direct readout from 0.0001 to 1000.0 volts, dc currents from 0.0001 to 1000.0 mA, ac volts from 0.0001 to 1000.0 volts rms, and resistance from 0.0001 to 10000 kΩ. Polarity indication is automatic when applicable.

1-6. Manual range selection is a standard feature with all options and is controlled from the front panel. Autoranging is optional, and is provided in the form of a single plug-in card.

1-7. The unit has 20 per cent overranging capability on all measurement functions, which provides a full scale readout of 12000. When the measurement exceeds the overranging limit, the overange indicator (a flashing red light on the front panel) is activated. When autoranging is included, the range is increased to the next higher range automatically when a readout of 12000 is exceeded. Similarly, the instrument will downrange if the magnitude of the unknown signal is less than 00980.

1-8. Measuring accuracy achieved in the Model 7000 is attributed directly to the dual slope integration technique. Dual slope integration is a two step process. In the first step, the unknown input is fed through an operational amplifier to an integrating capacitor. The integrator output is an increasing voltage with a slope that is proportional to the input. Integration time is controlled by counting 10,000 pulses from a

clock oscillator. In step two, the integrator input is switched to an internal reference current, and the integrator output is driven back to zero. The slope of the decreasing voltage is proportional to the reference current, and the time required to return the voltage to zero is directly proportional to the unknown input. This time is measured by counting pulses from the same clock oscillator used in step one. The count is displayed as the digital readout.

1-9. Since the same integrating components and the same clock oscillator are used in both steps, any shifts in values of components, due to temperature changes or aging, become self-cancelling. Because the second step is a direct comparison to the internal reference current, the instrument has excellent long term stability. No hourly or daily calibration adjustments are required; in fact, the calibration controls have been removed from the front panel.

1-10. OPTIONS

1-11. Accurate measurement of dc voltage is performed with the basic version of the Model 7000. The addition of optional plug-in boards permits the instrument to measure dc currents, ac voltage, and resistance. Autorange and BCD readout options are available also. Any or all of these options may be added to the Model 7000, depending on the user's requirements. Installation of the options is discussed in section II of this manual. A brief description of each option is given below:

OPTION 01 — AUTORANGE: Provides autoranging circuitry. The micrologic elements in the plug-in initiate an up-range pulse when the readout exceeds 12000 and a down-range pulse when the readout falls to 00980 or lower.

OPTION 02 — AC VOLTS: Utilizes an averaging technique, that gives a readout that is a true representation of the rms value of a sine wave input. Readout range is from 0.0001 to 1000.0 volts rms. The optional plug-in contains circuitry that converts the unknown ac input signal to an equivalent dc voltage that is then measured by the dc voltage measuring section of the instrument.

OPTION 03 — RESISTANCE: Utilizes an ohms-converter to provide resistance measurements from 0.0001 kΩ to 10 MΩ. Circuitry within the plug-in assembly directs a calibrated current through the unknown resistance, and the resulting dc voltage drop is measured by the dc voltage measuring section of the instrument.

OPTION 04 — DC CURRENT: Allows measurement of dc currents ranging from 0.0001 mA to 1000.0 mA. The optional plug-in contains current shunts so that for a given range, the current to be measured is directed through a calibrated resistance, and the resulting dc voltage is measured by the dc voltage measuring section of the instrument.

OPTION 05 — 1-2-4-8 BCD: Provides a 1-2-4-8 binary coded decimal output for use with external data logging equipment, etc.

1-12. ELECTRICAL SPECIFICATIONS

1-13. Table 1-1 contains electrical specifications for the Model 7000 Digital Multimeter.

1-14. DIMENSIONS AND WEIGHT

1-15. Figure 1-1 is an outline drawing of the Model 7000 showing principal dimensions in inches and centimeters. The weight of the instrument with no options installed is 12 lb/5.5 kg (15 lb/6.8 kg with all options installed).

Table 1-1. Specifications

GENERAL	
Input Power:	115 Vac or 230 Vac ±10%. 50 Hz to 400 Hz, 20 W.
Isolation:	500 V to case and power line ground.
Polarity Selection:	Automatic.
Overload Indication:	Flashing red light.
Readout:	Measurement function, four digits of data (with decimal point) and polarity plus an overrange digit displayed by 6 long life, side viewing, neon glow numerical display tubes and a function indicator lamp.
Dimensions:	12"depth x 5 1/4" height x 8 3/8" width (31 x 13 x 21 cm).
Weight:	12 lb. (5.5 kg). 15 lb. (6.8 kg) maximum with all options.
DC VOLTS	
DC Ranges: (Manual and Auto)	Four Ranges: 1.0000 V full scale + 20% overrange. 10.000 V full scale + 20% overrange. 100.00 V full scale + 20% overrange. 1000.0 V full scale.
Accuracy:	±0.01% of reading, ±0.01% of full scale.
Resolution:	100 μV (1 V range).
Integration Time:	50 msec.
Measurement Time:	200 msec.
Step Response Time:	650 msec to read within specified accuracy of final value without a range change.

Table 1-1. Specifications (Cont)

DC VOLTS (Cont)	
Input Impedance:	1 V . . . . . > 1 kMΩ. 10 V . . . . . > 1 kMΩ. 100 V . . . . > 10 MΩ. 1000 V . . . > 10 MΩ.
Temperature Coefficient:	±0.002% of reading, ±0.0008% of full scale/°C.
Voltage Coefficient:	±0.00005%/V if input exceeds 500V.
Temperature Range:	+5° to +45°C.
Normal Mode Rejection:	> 30 db at 60 Hz. > 40 db at 120 Hz. > 50 db at 400 Hz.
Overload Protection:	1.2 kV maximum on any range with no damage.
AC VOLTS (Option 02)	1.0000 V full scale + 20% overrange. 10.000 V full scale + 20% overrange. 100.00 V full scale + 20% overrange. 1000.0 V full scale.
Accuracy:	50 Hz to 10 kHz . . . ±0.1% of reading, ±0.03% of full scale. 10 kHz to 30 kHz . . ±0.3% of reading, ±0.05% of full scale. 30 kHz to 100 kHz . . ±1.0% of reading, ±0.2% of full scale.
Input Impedance:	1 megohm shunted by 50 pF.
Temperature Coefficient:	50 Hz to 10 kHz . . ±0.005% of reading, ±0.0015% of full scale °C. 10 kHz to 30 kHz . . ±0.01% of reading, ±0.003% of full scale °C. 30 kHz to 100 kHz . . ±0.05% of reading, ±0.01% of full scale °C.
Maximum Input Voltage: (Any Range)	50 Hz to 10 kHz . . . 1000 V. 10kHz to 20kHz . . . 750 V. 20 kHz to 50 kHz . . 500 V. 50 kHz to 100 kHz . 350 V.
Voltage Coefficient:	±0.0005%/V if input exceeds 500 V.

Table 1-1. Specifications (Cont)

AC VOLTS (Option 02) (Cont)

Integration Time:	50 msec.
Measurement Time:	1 sec.
Full Scale Step Response Time:	10 sec.

OHMS (Option 03)

Ranges:	1.0000 kΩ full scale + 20% overrange. 10.000 kΩ full scale + 20% overrange. 100.00 kΩ full scale + 20% overrange. 1000.0 kΩ full scale + 20% overrange. 10000 kΩ full scale.
Accuracy:	1 kΩ to 100 kΩ . ±0.05% of reading, ±0.02% of full scale. 1 MΩ . . . . . ±0.10% of reading, ±.03% of full scale. 10 MΩ . . . . . ±0.2% of reading, ±.05% of full scale.
Resolution:	100 mΩ (1 kΩ range).
Integration Time:	50 msec.
Measurement Time:	200 msec.
Step Response Time:	1 to 100 kΩ . . 1 sec. 1 MΩ . . . . . 5 sec. 10 MΩ . . . . 20 sec.
Overload Protection:	Maximum of 200 V may be applied without damage.
Temperature Coefficient:	1 k to 1 MΩ. . . ±0.005% of reading, ±0.0015% of full scale/°C. 10 MΩ . . . . . ±0.005% of reading, ±0.005% of full scale/°C.
Measurement Current:	1 kΩ to 10 kΩ range. . . .1 mA. 100 kΩ range. . . . . 100 μA. 1 MΩ . . . . . 1.0 μA. 10 MΩ . . . . . 1.0 μA.

Table 1-1. Specifications (Cont)

DC CURRENT (Option 04)	
Ranges:	1.0000 mA full scale + 20% overrange. 10.000 mA full scale + 20% overrange. 100.00 mA full scale + 20% overrange. 1000.0 mA full scale.
Accuracy:	±0.13% of reading, ±0.02% of full scale.
Resolution:	100 nA (1 mA range).
Integration Time:	50 msec.
Measurement Time:	200 msec.
Step Response Time:	650 msec.
Temperature Coefficient:	±0.003% of reading, ±0.0008% of full scale/°C.
Overload Protection:	Maximum of 2 A may be applied safely to any range without damage.
Input Impedance:	1 mA . . . . . 1 kΩ. 10 mA . . . . 100 Ω. 100 mA . . . 10 Ω. 1000 mA . . . 1 Ω.
AUTO RANGE (Option 01)	
Up Range Point:	1.2000 -0, + 9 digits 12.000 -0, + 9 digits 120.00 -0, + 9 digits
Down Range Point:	00.980 + 0, - 9 digits 009.80 + 0, - 9 digits 0098.0 + 0, - 9 digits

Table 1-1. Specifications (Cont)

AUTO RANGE (Option 01) (Cont)

Range Response Time:	Typical	Worse Case
VDC	250 msec	1 sec.
VAC	3 sec	20 sec.
kΩ	250 msec	20 sec.
mA	250 msec	1 sec.

BCD OUTPUT CODING (Option 05)

1-2-4-8 Positive Time Logic:	Numbers, Decimal Point, Polarity, and Function indicated by a "0" state of +0.5V and a "1" state of +5V.

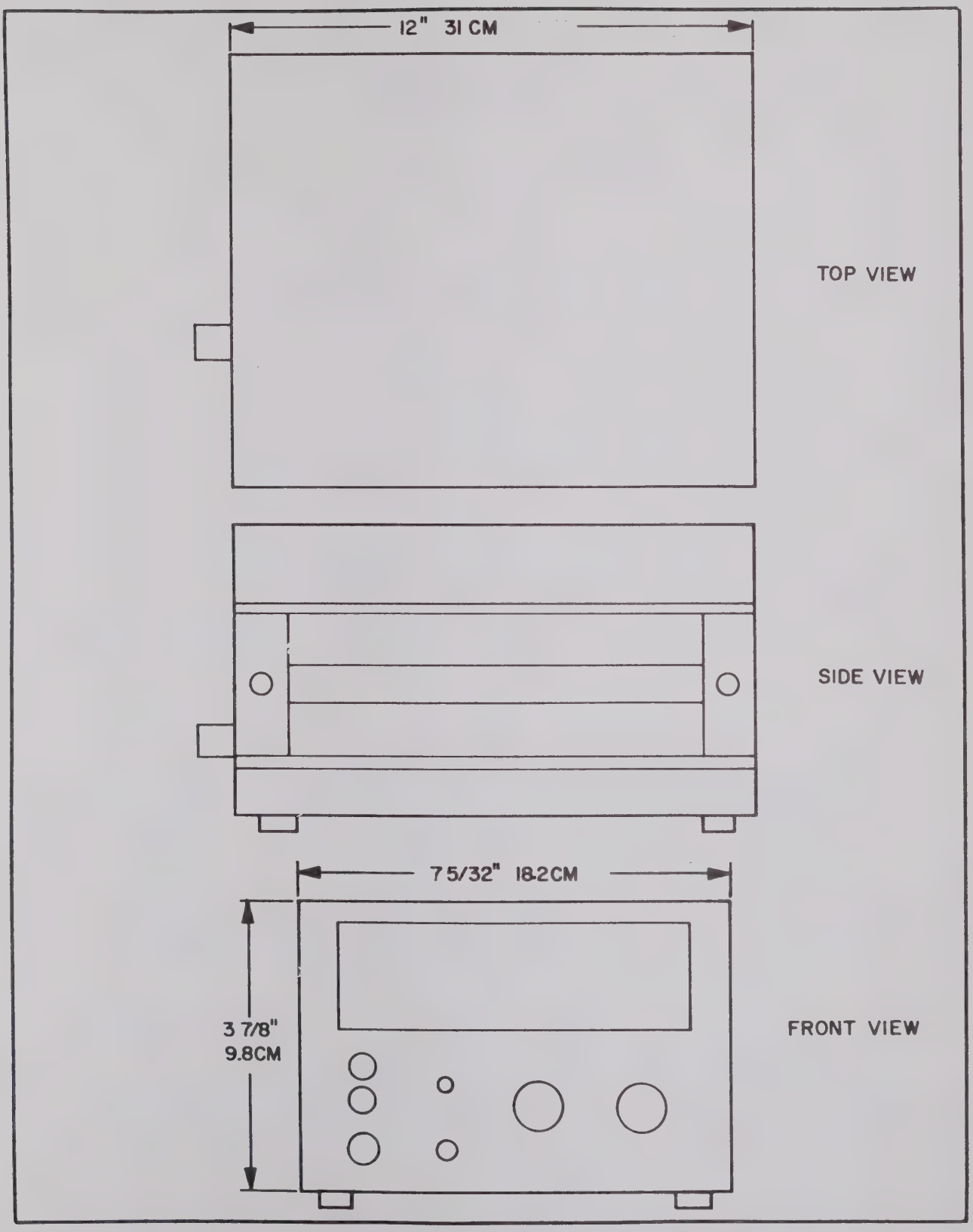


Figure 1-1. Dimensions of the Model 7000

SECTION II

INSTALLATION

2-1. INTRODUCTION

2-2. This section outlines procedures for inspection and initial installation. Reshipment instructions are included in case the instrument must be returned to Fairchild Instrumentation.

2-3. UNPACKING AND INSPECTION

2-4. Before accepting the instrument from the shipper, the crated instrument should be inspected for external damage. Any sign of external damage must be noted by both customer and shipper, and should be called to the attention of the insurance investigator.

2-5. As soon as the equipment is unpacked, inspect the instrument for damage in shipment; check for scratches or dents and damaged knobs or connectors. Remove top cover plate and make sure that all plug-in boards are seated firmly in their sockets. If damage is noted, do not use the instrument unless instructed by the insuring agency.

2-6. POWER REQUIREMENTS

2-7. The Model 7000 is designed to operate from a 115/230 V, 50 to 400 Hz power source. Do not connect the instrument to a power source with incorrect voltage or inadequate current rating. The 115/220 V switch (located on the rear panel of the instrument directly above the power cord plug) should be set to the appropriate position, i.e., 115 for 115 V operation, 230 for 230 V operation.

2-8. The Model 7000 is equipped with a three-conductor power cable that grounds the instrument when the connector is plugged into an appropriate receptacle. To preserve this safety feature when operating with a two-contact outlet, use an adapter and connect the pigtail on the adapter to a suitable ground.

2-9. OPERATIONAL CHECK

2-10. The following preliminary operation check may be used to ensure that all components and circuits are in operating condition when the instrument is first operated. The procedure provides a quick check for proper functioning, but does not check specifications completely. Refer to paragraph 5-6 for the complete performance check.

a. Connect instrument to ac power source. Be sure that 115/230 V switch is in appropriate position. Switch PWR ON switch to upper position. Display panel should light up.

b. Set FUNCTION switch to TEST.

c. Set Range switch to 1 V Range.

d. Readout should indicate 0.1000 ±1 digit after a short warm up period.

2-11. RESHIPMENT

2-12. When an instrument is damaged in shipment, do not return it to Fairchild Instrumentation without specific instructions from the insuring agency. Neither the customer nor Fairchild is required to assume responsibility for reshipment.

2-13. When a damaged instrument is to be returned to the factory for service or repair, contact your nearest Fairchild Instrumentation engineering representative for written permission to ship, shipping instructions, and a shipping form.

2-14. FIELD INSTALLATION OF OPTION BOARDS

2-15. The addition of each of the options offered with the Model 7000 requires simple insertion of the applicable plug-in board. When installing an optional plug-in board, the following steps should be taken:

a. Remove all signal inputs to the instrument and turn power off.

b. Remove top cover to expose printed circuit board plug-in connectors.

c. Insert optional printed circuit board into appropriate connector and press firmly in place.

Option	Socket
01	XA4
02	XA9
03	XA10
04	XA14

d. (BCD OPTION ONLY). The BCD option requires additional installation of a rear panel connector, and an interconnect cable (one assembly). Route the interconnect cable through predrilled hole (see figure 2-1) and to rear panel of chassis. Mount the Amphenol 50 pin connector using the two screws supplied.

e. Proceed to section V of this manual to check and adjust calibration of the instrument.

SECTION III

OPERATION

3-1. INTRODUCTION

3-2. The Model 7000 Digital Multimeter will measure dc voltage, and, with the inclusion of optional plug-in circuit boards, ac voltage, dc current, and resistance. Also, the unit has provisions for BCD outputs (1-2-4-8 code) and autoranging which is operational for all measurement functions. The full potential of this instrument can be realized only when the user has gained full appreciation of its operating principles and control functions. This section defines functions of the controls and provides instructions to be observed when making measurements.

3-3. OPERATING CONTROLS

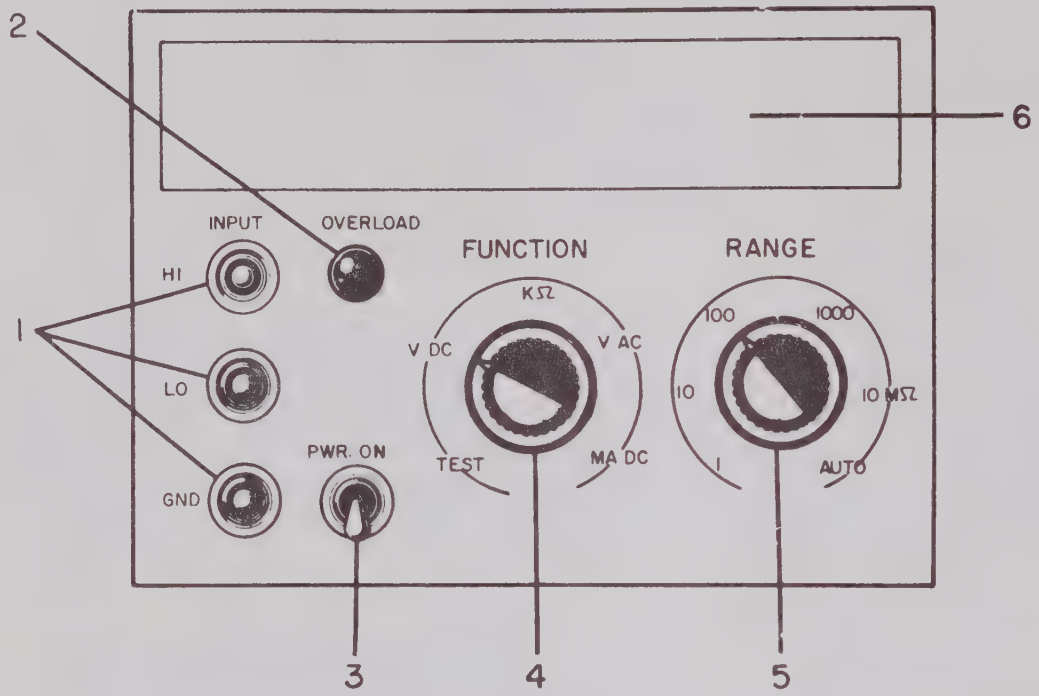
3-4. The function of each control located on the front panel is described in figure 3-1. Figure 3-2 describes the rear panel controls and connectors.

3-5. OPERATING INSTRUCTIONS

NOTE

Before attempting measurements with the instrument, it is recommended that its operation be checked with the SELF CHECK procedure outlined in figure 3-3.

3-6. Figures 3-4 through 3-11 outline instructions for making measurements with Model 7000. Each figure discusses a particular mode of operation. The number or numbers associated with each control indicate the step in which the control is used.



1. HI, LO, and GND terminals are input connectors for floating or grounded sources.

2. OVERLOAD indicator flashes when amplitude of input signal exceeds range setting.

3. PWR ON switch applies primary power to instrument. ON position is up.

4. FUNCTION switch:

   a. Connects instrument self check feature into circuit when switched to TEST. Readout should be 0.1000 when the RANGE switch is in 1 position.

   b. Permits measurement of dc volts when switched to VDC.

   c. Permits measurement of resistance when switched to kΩ (an optional feature).

   d. Permits measurement of ac volts when switched to VAC (an optional feature).

   e. Permits measurement of dc current when switched to MA DC (an optional feature).

5. RANGE Control:

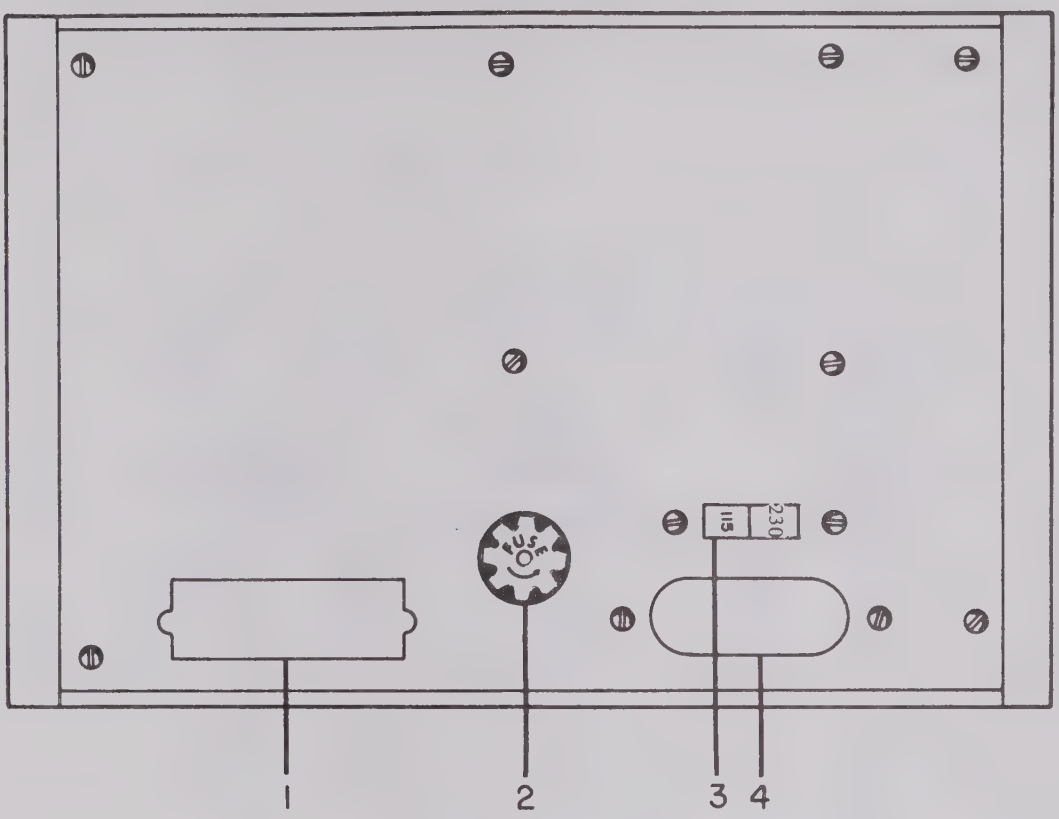
   a. Selects automatic ranging when switched to AUTO (an optional feature).

   b. Selects instrument readout range.

1	x.xxxx
10	xx.xxx
100	xxx.xx
1000	xxxx.x
10 MΩ	xxxxx (kΩ mode only)

6. READOUT Panel:
Five digits of data (including one overrange digit), decimal point, function and polarity are presented visually.

Figure 3-1. Front Panel Description



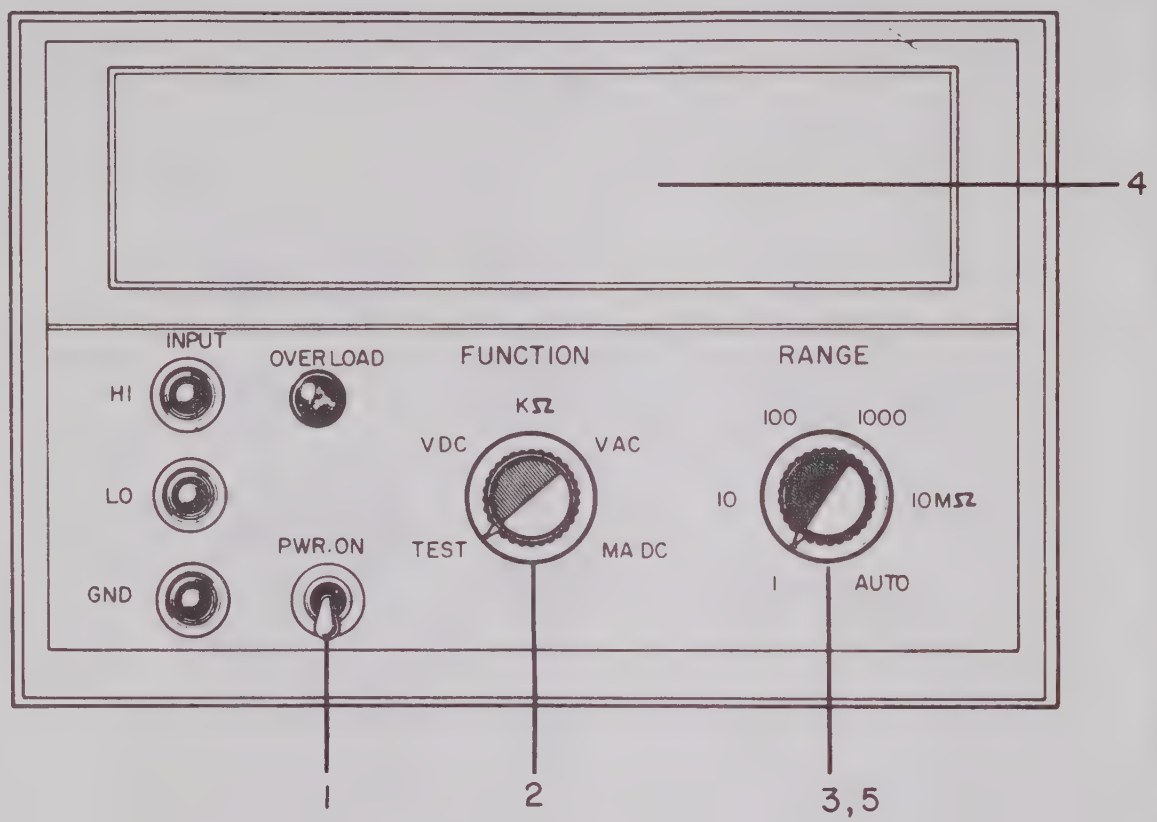
1. BCD connector (part of Option 05). 50-pin Amphenol connector provides a 1-2-4-8 binary coded decimal output for use with external data logging equipment.

2. FUSE provides overload protection. Replacement value is 1/2 ampere, slow-blow.

3. 115 V/230 V switch permits selection of power input from either 115 Vac or 230 Vac source.

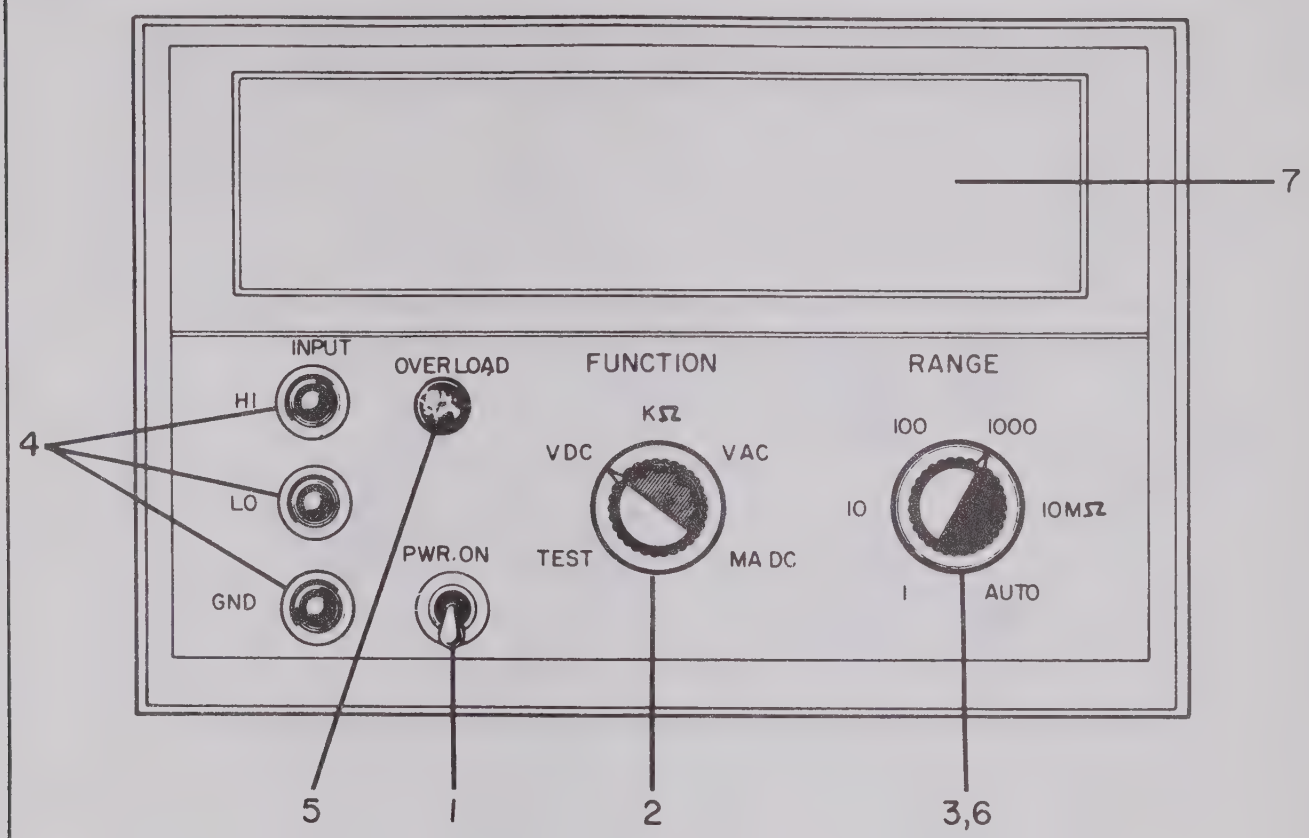
4. Input power connector provides terminals for the three wire plug on power cable. Input can be 115 V/230 V, 50 to 400 Hz.

Figure 3-2. Rear Panel Description



1. Connect instrument to ac power source. Set PWR ON switch to on (up).
2. Set FUNCTION switch to TEST.
3. Set RANGE switch to 1.
4. Check that readout is 0.1000 ±1 digits.
5. Change Range and check that decimal point is positioned correctly for each range.

Figure 3-3. Self Check



1. Connect instrument to ac power source. Set PWR ON switch to on (up).

2. Set FUNCTION switch to VDC.

3. Set RANGE switch to 1000.

4. Connect HI, LO, and GND terminals to unknown dc voltage source. Voltage amplitude must be in the 0 to 1000.0 V range.

NOTE

The terminals must be used correctly to reduce ground loop currents to a minimum and achieve best measurement accuracy. When measuring a low level, high impedance source with its own ground, connect GND terminal to the source ground and the HI and LO terminals to the high and low outputs of the source. For all other measurements, connect the GND and LO terminals to one measurement point and the HI terminal to the other.

5. If OVERLOAD indicator is flashing, input voltage is beyond range of instrument. Disconnect instrument from voltage source.

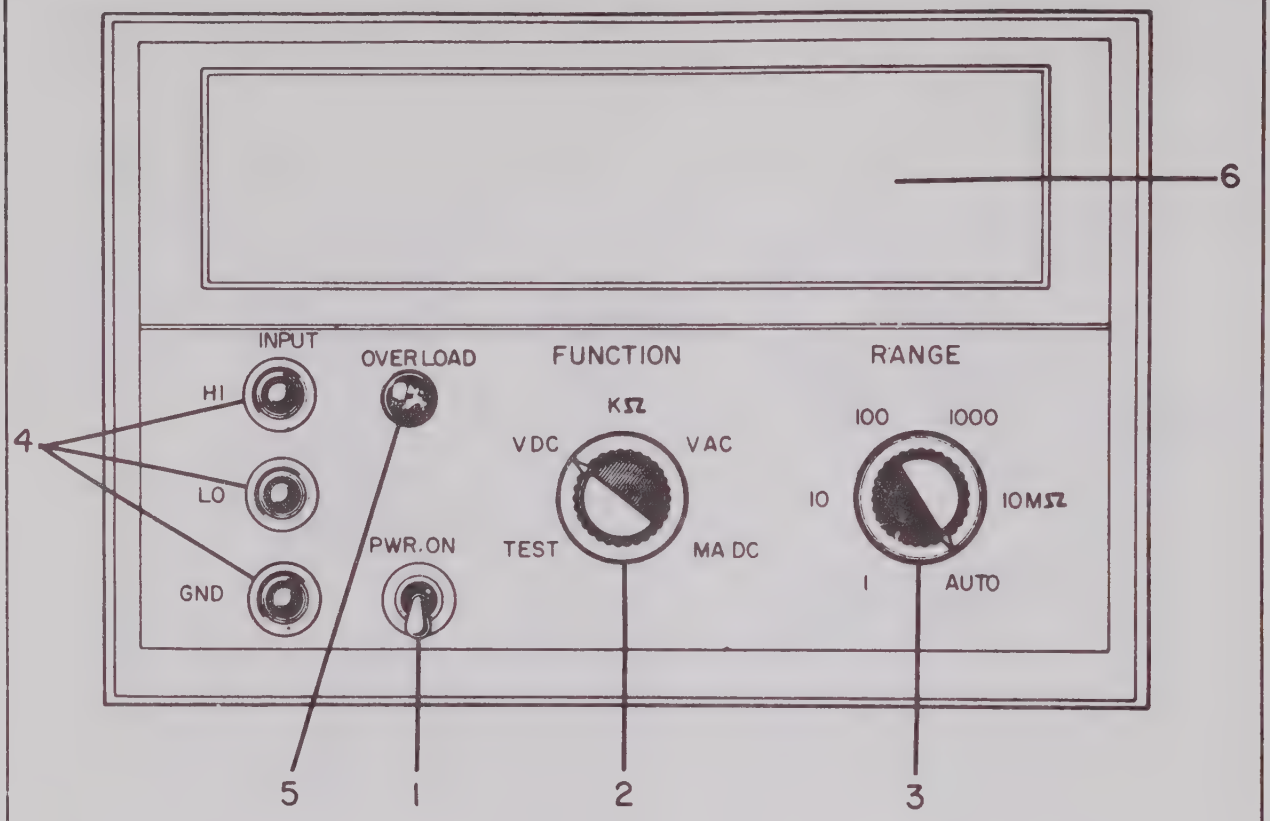
6. Progressively select lower RANGE settings until correct range is reached.

7. Read voltage on display. Decimal point is correctly positioned. Measurement unit (VDC) and polarity are displayed.

CAUTION

THE MEASURING CIRCUIT IS FLOATED FROM THE CHASSIS GROUND OF THE INSTRUMENT. THE POTENTIAL APPLIED BETWEEN LO AND GND MUST NOT EXCEED 500 V OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Figure 3-4. DC Voltage Measurements, Manual Ranging



1. Connect instrument to ac power source. Set PWR ON switch to on (up).

2. Set FUNCTION switch to VDC.

3. Set RANGE switch to AUTO.

4. Connect HI, LO, and GND terminals to unknown dc voltage source. Voltage amplitude must be in the 0 to 1000.0 Vdc range.

NOTE

The terminals must be used correctly to reduce ground loop currents to a minimum and achieve best measurement accuracy. When measuring a low level, high impedance source with its own ground, connect GND terminal to the source ground and the HI and LO terminals to the high and low outputs of the source. For all other measurements, connect the GND and LO terminal to one measurement point and the HI terminal to the other.

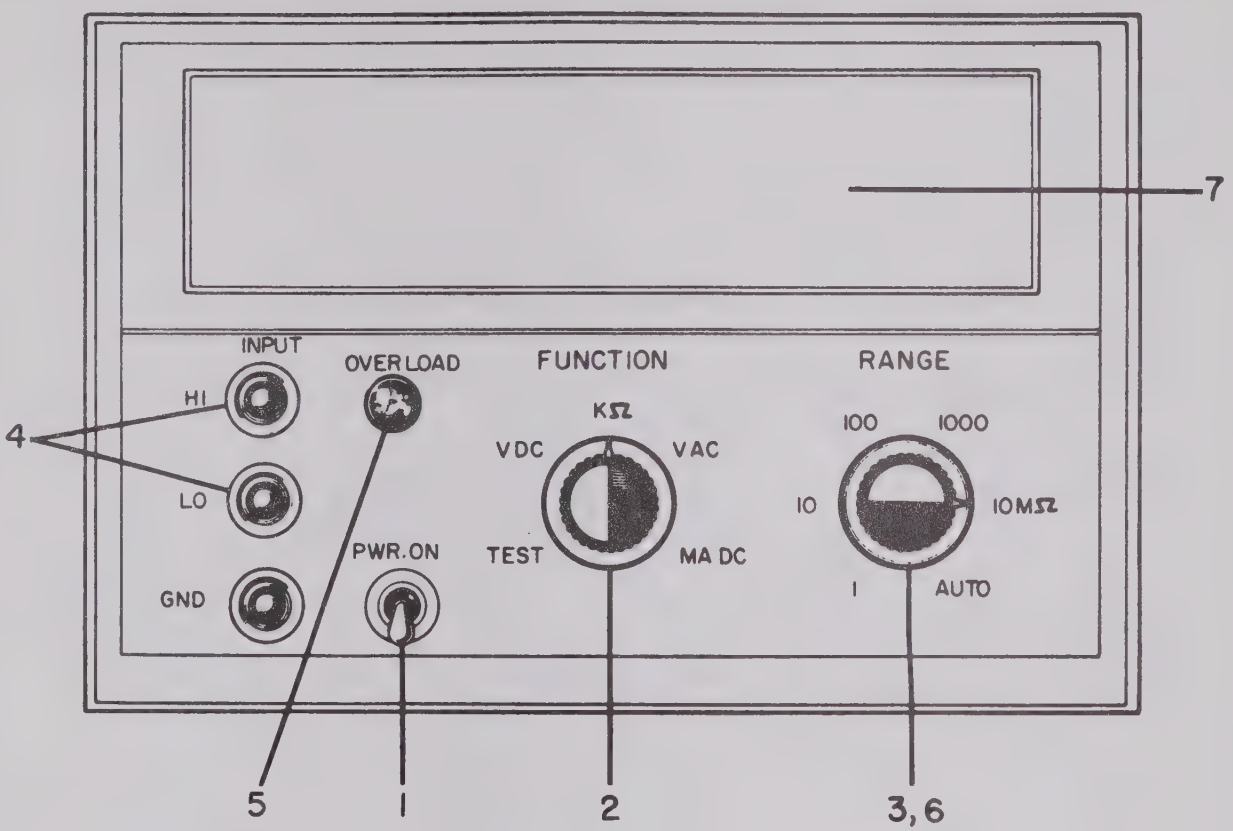
5. If OVERLOAD indicator is flashing, input voltage is beyond range of instrument. Disconnect instrument from unknown voltage source.

6. Read voltage on display. Decimal point is correctly positioned. Measurement unit (VDC) and polarity are displayed.

CAUTION

THE MEASURING CIRCUIT IS FLOATED FROM THE CHASSIS GROUND OF THE INSTRUMENT. THE POTENTIAL APPLIED BETWEEN LO AND GND MUST NOT EXCEED 500 V OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Figure 3-5. DC Volts Measurements, Auto Ranging

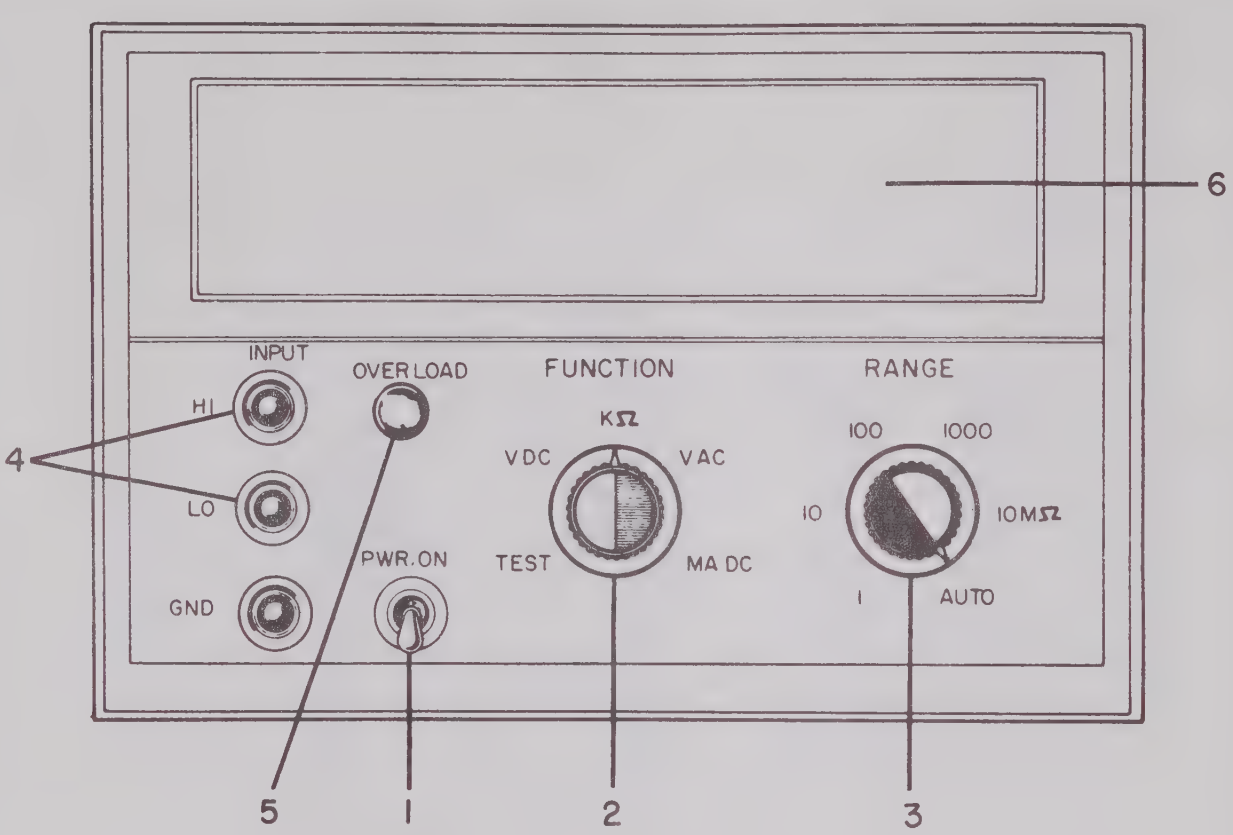


1. Connect instrument to ac power source. Set PWR ON switch to on (up).
2. Set FUNCTION switch to KΩ.
3. Set RANGE switch to10MΩ.
4. Connect unknown resistance across HI and LO terminals.
5. If OVERLOAD indicator is flashing, value of resistance under test is beyond measurement range of instrument.
6. Progressively select lower RANGE settings until correct range is reached.
7. Read resistance on display. Decimal point is correctly positioned and measurement unit (KΩ) is displayed.

CAUTION

DO NOT CONNECT A CONSTANT VOLTAGE SOURCE TO THE INSTRUMENT WITH THE FUNCTION SWITCH IN THE KΩ POSITION. VOLTAGE IN EXCESS OF 200V WILL DAMAGE THE INSTRUMENT.

Figure 3-6. Resistance Measurements, Manual Ranging

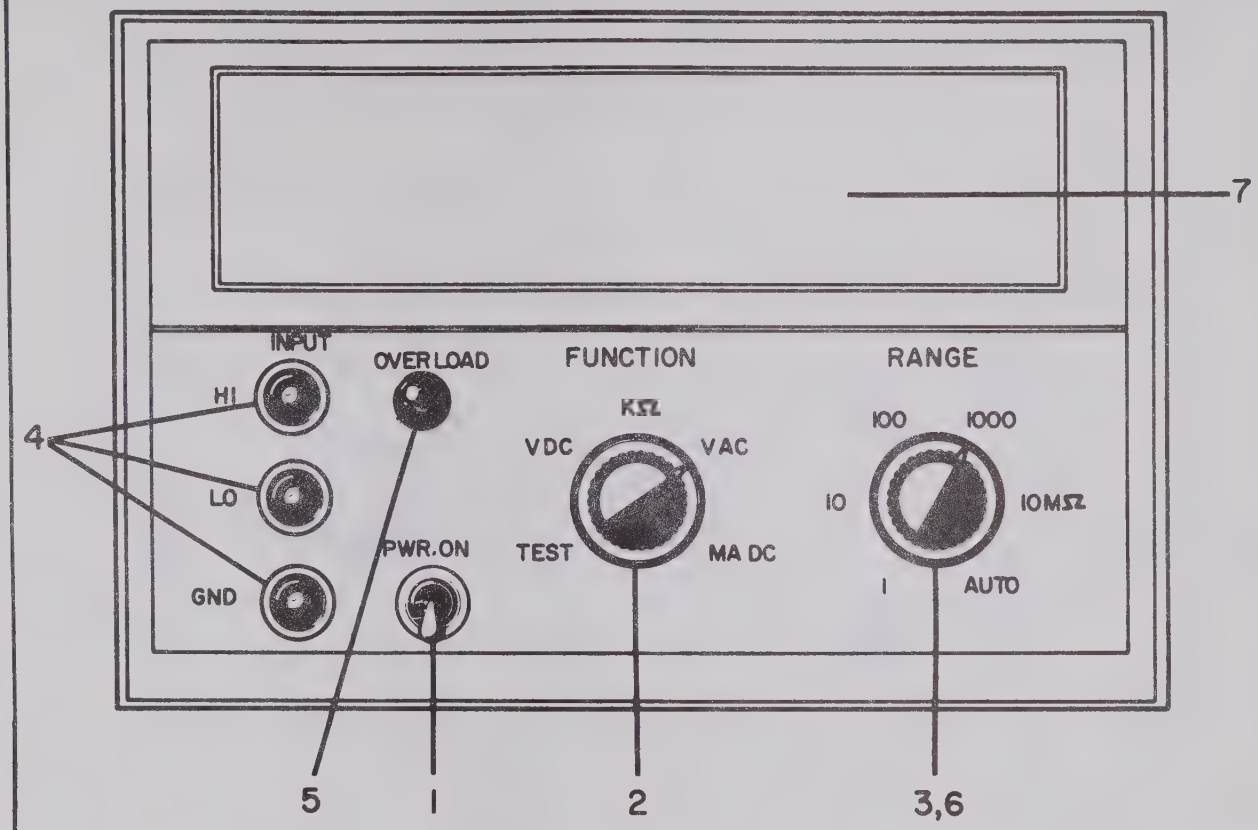


1. Connect instrument to ac power source. Set PWR ON switch to on (up).
2. Set FUNCTION switch to KΩ.
3. Set RANGE switch to AUTO.
4. Connect unknown resistance across HI and LO terminals.
5. If OVERLOAD indicator is flashing, value of resistance under test are beyond measurement range of instrument.
6. Read resistance on display. Decimal point is displayed in correct POSITION.

CAUTION

DO NOT CONNECT A CONSTANT VOLTAGE SOURCE TO THE INSTRUMENT WITH THE FUNCTION SWITCH IN THE KΩ POSITION. VOLTAGE IN EXCESS OF 200V WILL DAMAGE THE INSTRUMENT.

Figure 3-7. Resistance Measurements, Auto Ranging



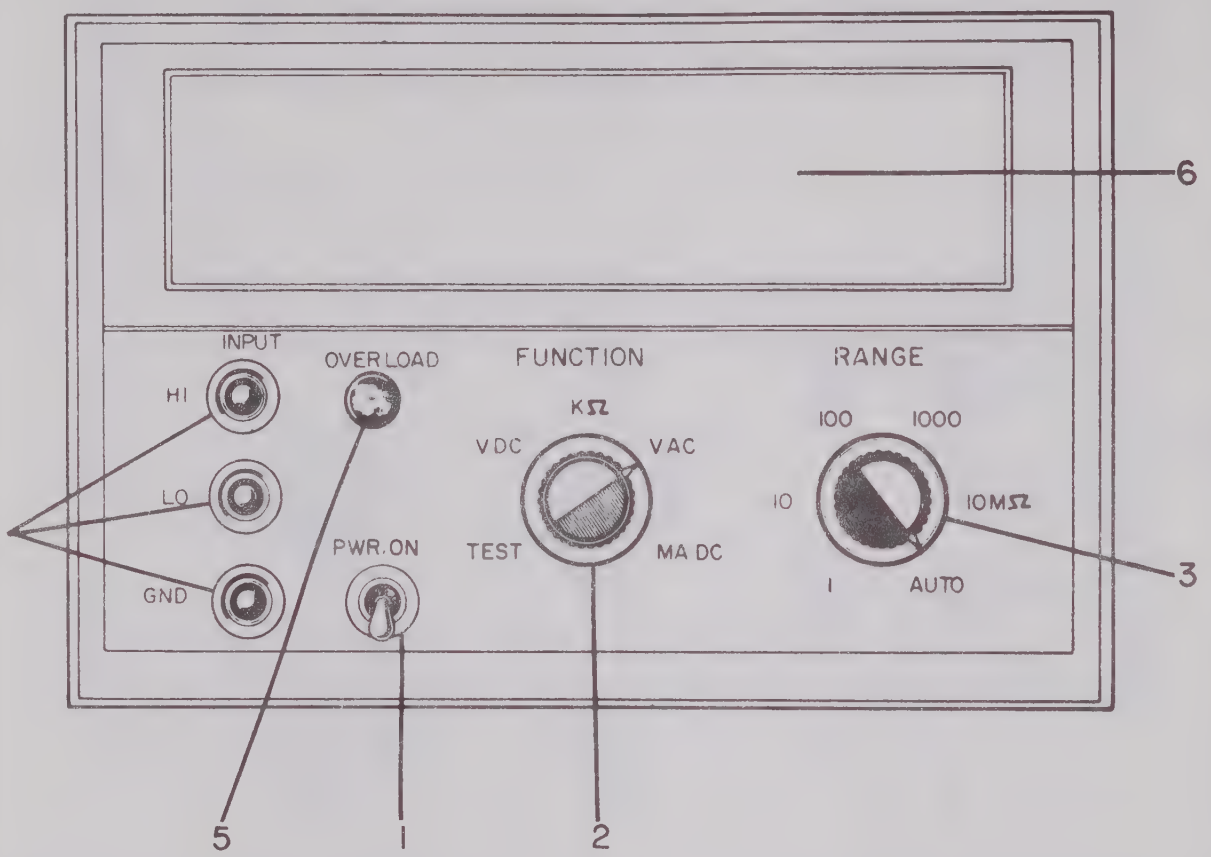
1. Connect instrument to ac power source. Set PWR. ON switch to on (up).
2. Set FUNCTION switch to VAC.
3. Set RANGE switch to 1000.
4. Connect HI, LO, and GND terminals to ac voltage source.
5. If OVERLOAD indicator is flashing, input voltage is beyond range of instrument. Disconnect instrument from voltage source.
6. Progressively select lower range settings until correct range is reached.
7. Read ac volts on display. Decimal point is correctly positioned and measurement unit (VAC) is displayed.

CAUTION

MAXIMUM ALLOWABLE INPUT VOLTAGE IS FREQUENCY DEPENDENT. DO NOT EXCEED LIMITS LISTED BELOW OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Frequency	Maximum Input Voltage
50 Hz to 10 kHz	1000 V
10 kHz to 20 kHz	750 V
20 kHz to 50 kHz	500 V
50 kHz to 100 kHz	350 V

Figure 3-8. AC Voltage Measurements, Manual Ranging



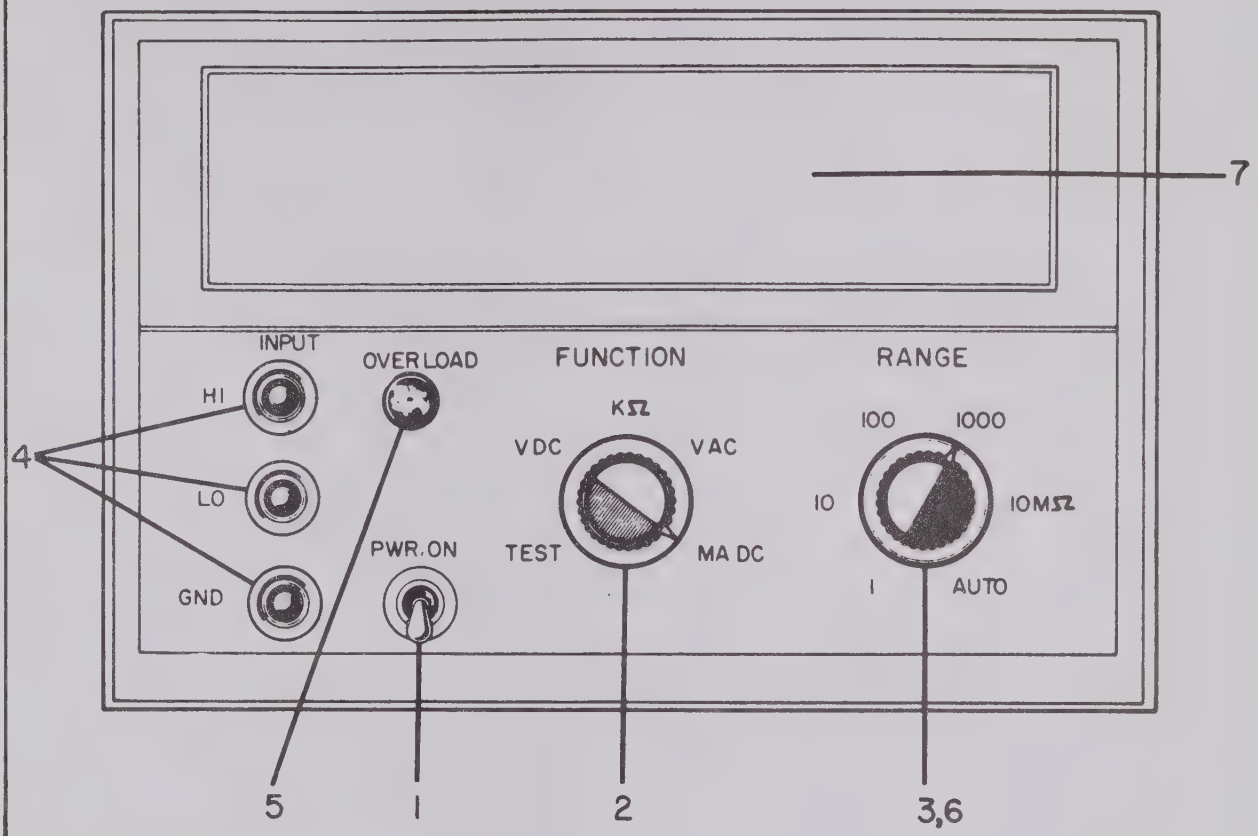
1. Connect instrument to ac power source. Set PWR. ON switch to on (up).
2. Set FUNCTION switch to VAC.
3. Set RANGE switch to AUTO.
4. Connect HI, LO, and GND terminals to ac volts source.
5. If OVERLOAD indicator is flashing, input voltage is beyond range of instrument. Disconnect from voltage source.
6. Read ac voltage on display. Decimal point is correctly positioned and measurement unit (VAC) is displayed.

CAUTION

MAXIMUM ALLOWABLE INPUT VOLTAGE IS FREQUENCY-DEPENDENT. DO NOT EXCEED LIMITS LISTED BELOW OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Frequency	Maximum Input Voltage
50 Hz to 10 kHz	1000 V
10 kHz to 20 kHz	750 V
20 kHz to 50 kHz	500 V
50 kHz to 100 kHz	350 V

Figure 3-9. AC Voltage Measurements, Auto Ranging

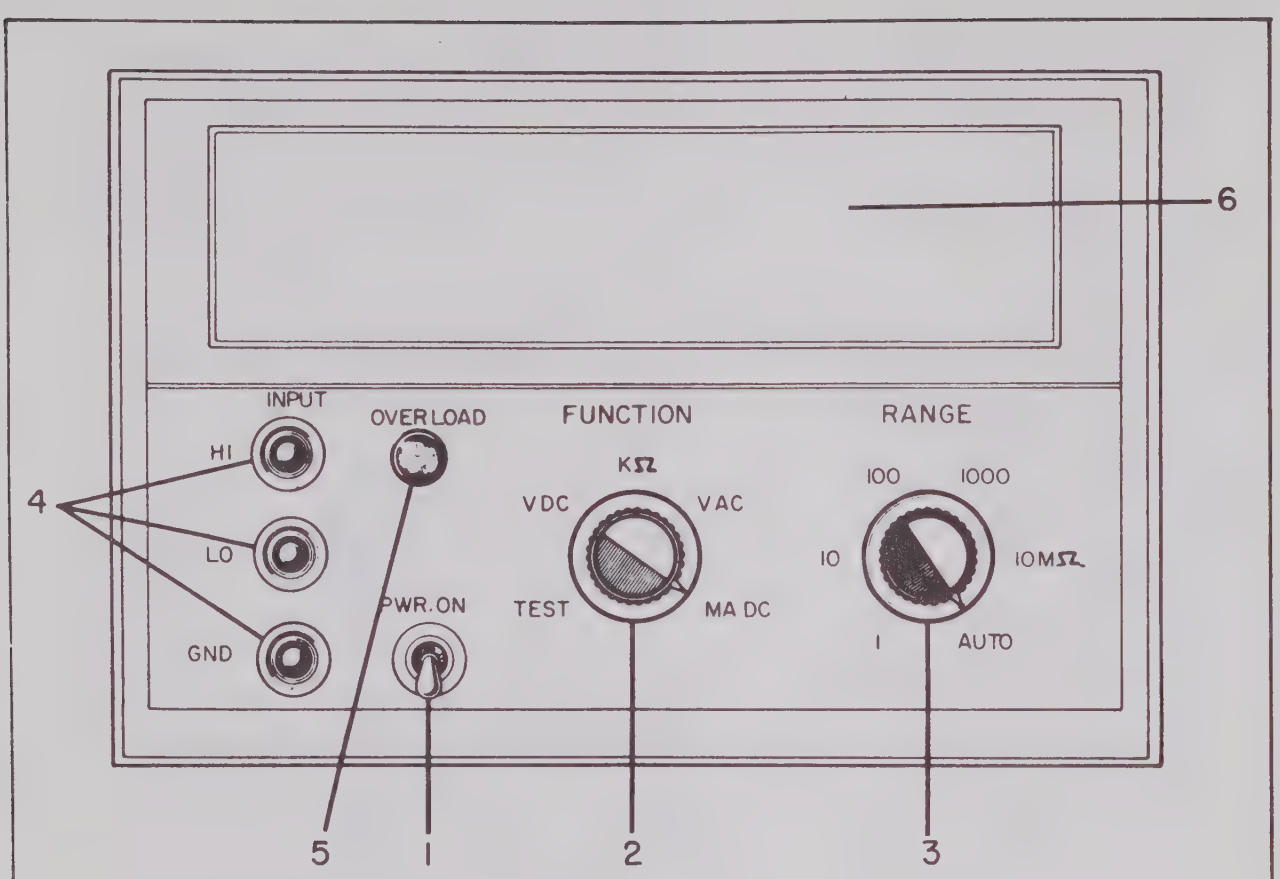


1. Connect instrument to ac power source. Set PWR. ON switch to on (up).
2. Set FUNCTION switch to MA DC.
3. Set RANGE switch to 1000.
4. Connect HI, LO, and GND terminals to dc current source.
5. If OVERLOAD indicator is flashing, input current is beyond range of instrument. Disconnect from current source.
6. Progressively select lower range settings until correct range is reached.
7. Read dc current on display. Decimal point is correctly positioned. Measurement unit (DC MA) is displayed.

CAUTION

A MAXIMUM OF 2 AMPERES MAY BE APPLIED TO ANY RANGE WITHOUT DAMAGE.

Figure 3-10. DC Current Measurements, Manual Ranging



1. Connect instrument to ac power source. Set PWR. ON switch to on (up).
2. Set FUNCTION switch to MA DC.
3. Set RANGE switch to AUTO.
4. Connect HI, LO, and GND terminals to dc current source.
5. If OVERLOAD indicator is flashing, input current is beyond range of instrument. Disconnect from current source.
6. Read dc current on display. Decimal point is correctly positioned and measurement (DC MA) is displayed.

CAUTION

A MAXIMUM OF 2 AMPERES MAY BE APPLIED TO ANY RANGE WITHOUT DAMAGE.

Figure 3-11. DC Current Measurements, Auto Ranging

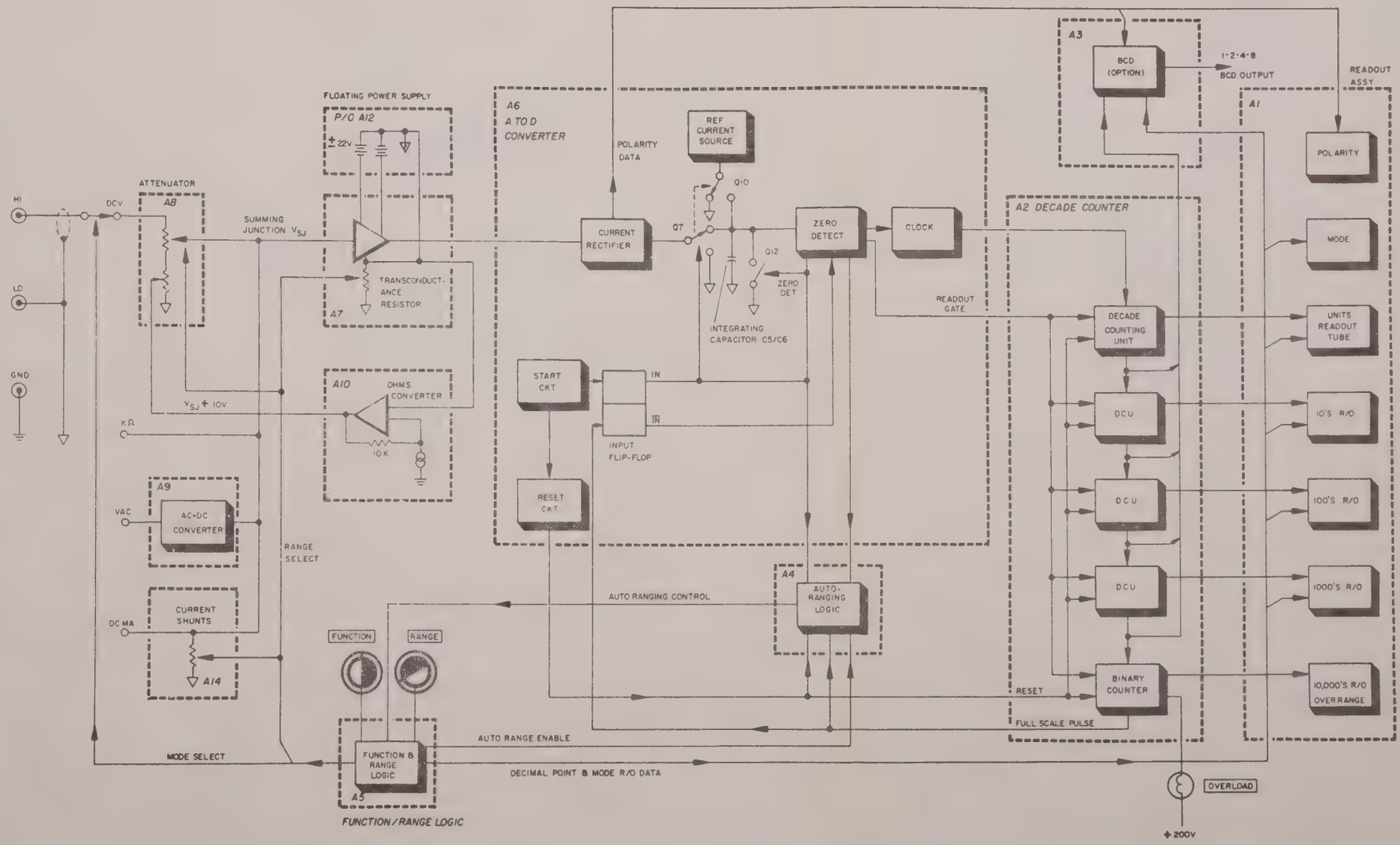


Figure 4-1. Block Diagram, Model 7000

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This section contains a discussion of the design and operating principles of the Fairchild Model 7000 Digital Multimeter. Theory of operation is discussed first at block diagram level and then at detailed circuit level. Complete schematic diagrams of circuits discussed in this section are included in section V of this manual.

4-3. OPERATING PRINCIPLES

4-4. Figure 4-1 is a block diagram of the instrument. To describe the basic measurement technique, assume that dc volts mode (VDC) of operation has been selected. (This function is chosen because the dc measurement circuitry is common to all modes of operation; the additional conversion required for optional measurements of resistance, dc current and ac voltage is described in later paragraphs.) The dc input voltage is coupled via dc attenuator A8 to input amplifier A7. This unit is a solid-state chopper-stabilized operational amplifier with a floating power supply and is connected to produce an output current directly proportional to the amplitude of the input voltage. Ranging resistors in the attenuator and the amplifier transconductance resistance are selected by the front panel RANGE switch (or automatically by optional autoranging assembly A4) to provide the same current level for each of the four input voltage ranges. The output of the amplifier is connected to a current rectifier on assembly A6 which gives an output current that is equal to the input current in magnitude, but is of negative polarity, regardless of the input current polarity. The current rectifier serves two purposes: it supplies a current proportional to the voltage being measured to integrating capacitor A6C5, A6C6 and it senses the polarity of the input voltage for display on the readout polarity indicator.

4-5. A measurement cycle consists of two parts. See figure 4-2. The first portion begins when the start circuit (a free-running multivibrator) generates a start pulse. The leading edge, (t_1 on figure 4-2) resets the decade counting units to 00000 and the trailing edge (t_2) sets the input flip-flop. The input flip-flop "IN" output closes solid-state switch A6Q7, coupling the output of the current rectifier to integrating capacitor A6C5/A6C6. Simultaneously, the input flip-flop "$\overline{\text{IN}}$" output controls a zero detector which a) enables the clock, allowing clock pulses to pass to the first decade counting unit and b) opens solid-state switch A6Q12, removing ground from integrating capacitor A6C5/A6C6. The output of the current rectifier now charges the integrating capacitor and clock pulses feed into the counter. The counter can hold 10,000 counts before overflowing to 00000. The four least significant digits are obtained from decade counters. Each counts 0 to 9. (The most significant digit is obtained from a binary counter and indicates 0 and 1 only.) When overflow occurs (t_3), a full scale pulse is generated that resets the input flip-flop.

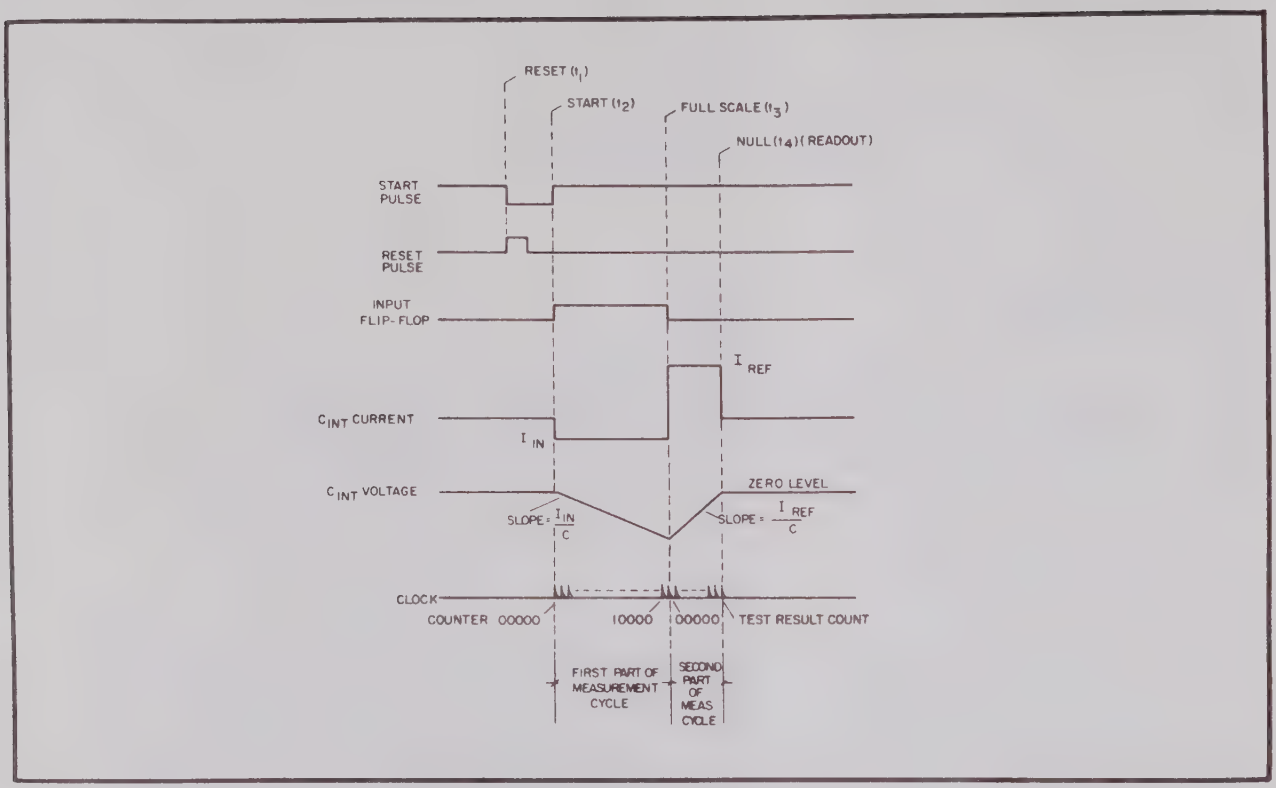


Figure 4-2. Test Sequence

4-6. The second portion of the measurement cycle now begins. The input flip-flop a) disconnects the integrating capacitor from the output of the current rectifier and connects it instead via solid state switch A6Q10 to a precision 1 mA constant current source having a positive output, and b) removes its control from the zero detector. However, due to the negative charge on the integrating capacitor at this time, the zero detector continues to allow clock pulses to reach the counter. The charge on the integrating capacitor returns to zero at a constant rate because the reference current is derived from a reference source that is stabilized and temperature compensated to a high degree. The time required for the charge to reach zero is proportional to the integrated unknown input current. Pulses counted during this period (t_3 to t_4) accumulate in the decade counter. The zero detector senses when the charge on the integrating capacitor reaches zero and when this occurs, the clock is inhibited. The instrument now holds the measured value and the decimal readout buffers are gated to show the counter setting. Counter capacity, clock frequency, and ranging are designed to give a readout in volts. When the input signal exceeds the range setting, an overload indicator (a flashing red light) is activated. Input to the overload indicator is taken from the binary counter so that as the most significant digit is counted the overload indicator is activated.

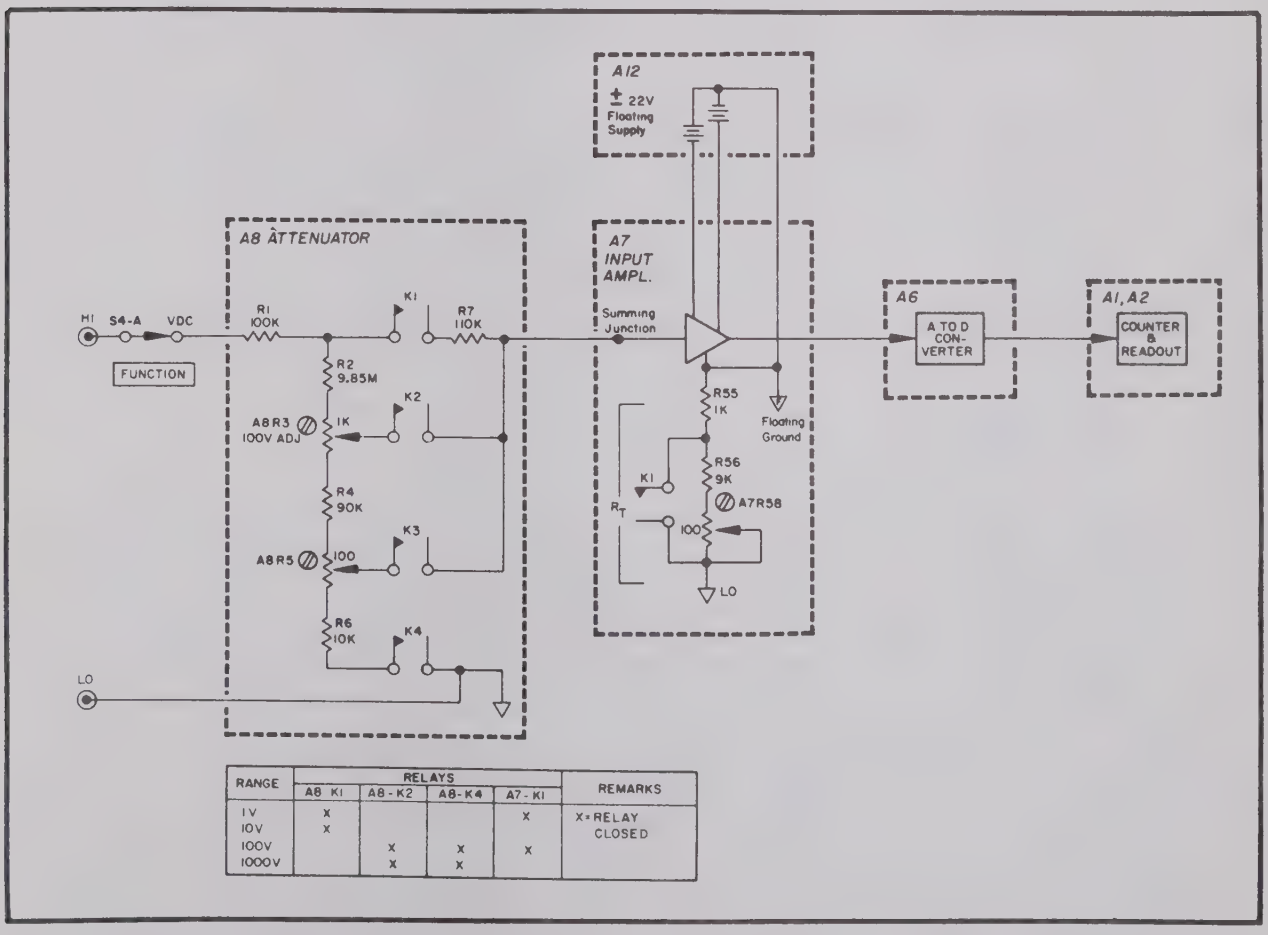
4-7. When VAC is selected, the ac input signal is converted to an equivalent dc voltage which then is measured by the dc volts circuitry previously described. The output of optional VAC assembly A9 produces a dc level proportional to the average value of the applied ac voltage. The instrument, however, is calibrated in such a manner that the rms value of a pure sine wave is indicated.

4-8. Dc current is measured by monitoring the voltage drop across a number of precision instrument shunts mounted on optional assembly A14. For all dc current ranges, the full scale voltage drop developed across these shunt resistors is 1.0 volts.

4-9. Resistance is measured by programing a constant current through the unknown resistance and measuring the resulting voltage drop with the basic dc measurement system. The optional ohms converter circuitry is mounted on assembly A10.

4-10. DC VOLTS MEASUREMENT

4-11. Figure 4-3 is a diagram of the dc measurement circuit showing in detail the operation of the function select switch and ranging relays. When either the 1 Vdc or 10 Vdc range is selected, relay A8K1 is closed by the function logic and applies the unknown voltage directly to the input of the chopper stabilized amplifier on assembly A7. (The amplifier is described in detail in paragraph 4-26.) The



RANGE	RELAYS				REMARKS
	A8 K1	A8-K2	A8-K4	A7-K1	
1V	X			X	X=RELAY CLOSED
10V	X				
100V		X	X	X	
1000V		X	X		

Figure 4-3. DC Voltage Measurement Circuit

input impedance of the amplifier is $>10^9$ Ω, and this is essentially the input impedance of the instrument on the 1 Vdc and 10 Vdc ranges. The amplifier generates a current that is proportional to the value of the input voltage, and an output of 1 mA full scale is chosen for all ranges. The amplifier transconductance resistor R_t is selected by relay A7K1 to program this current. For the 1 Vdc range, A7K1 is closed and R_t = 1 kΩ: for the 10 Vdc range A7K1 is open and R_t = 10 kΩ.

4-12. On the 100 Vdc and 1000 Vdc ranges, A8K1 is held open and A8K4 closed. This connects the input signal across a 100:1 attenuator network consisting of A8R2 through A8R6. On both the ranges, A8K2 is closed and picks off 1 V for a 100 V input and 10 V for a 1000 V input. Again, relay A7K1 is operated to give the chopper stabilized amplifier a 1 mA full scale current for a 1 V and 10 V input. (100 Vdc and 1000 Vdc ranges respectively.) The input impedance of the instrument on the two upper ranges is set by the resistance of the attenuator network at 10 MΩ.

4-13. RESISTANCE MEASUREMENT

4-14. Resistance is measured by programing a constant current through the unknown resistance and measuring the resulting voltage drop with the basic dc measurement system. A block diagram of the resistance measurement circuit is shown in figure 4-4. Relay A10K1 is closed by the function logic when the kΩ mode is selected. A feedback circuit consisting of bootstrap amplifier A10 and ranging resistors programed by relays A8K1, A8K2, and A8K3 acts as a constant current generator to supply a test current of 1 μA, 100 μA, or 1 mA. The bootstrap amplifier output is equal to the voltage at the summing junction (input of amplifier A7) plus 10 volts. This maintains 10 volts across the current programing resistance. The test current through the unknown resistance is therefore 10 V/R_{Range}. The dc voltage appearing at the input of amplifier A7 is proportional to the value of unknown resistance. By suitable switching of range resistors on A8 and transconductance resistor on A7, five ranges of resistance readout can be obtained. Relay operation summarized in figure 4-4.

4-15. OHMS CONVERTER A10

4-16. The ohms converter is a bootstrap amplifier which provides an output voltage equal to its input voltage plus 10 volts. A simplified schematic of the circuit is shown in figure 4-5. Transistors A10Q1A and A10Q1B comprise a differential amplifier with A10Q3 and A10Q4 acting as output stages. The base of A10Q1A is tied to the floating ground on input amplifier A7 and the base of A10Q1B is connected to a 1 mA constant current generator. A feedback resistance of 10 kΩ (A10R11) is connected between the output and the inverting input (base of A10Q1B). This bootstrap configuration maintains 10 volts across the feedback resistance holding the output voltage to the voltage at the input plus 10 volts. The constant current generator is comprised of A10Q5, A10Q6, A10Q7A and A10Q7B. Zener diode CR5 provides a reference voltage of 6.8 volts. This voltage is maintained across A10R19 causing a constant current of 1 mA to flow in the collector circuit of A10Q7A. Feedback between the output and input is via resistors A10R14, A10R13, A10R12, A10R11 and potentiometer A10R8. The shorts across A10R12, and A10R13, and A10R14 may be removed for coarse adjustment, while A10R8 is made adjustable for fine calibration.

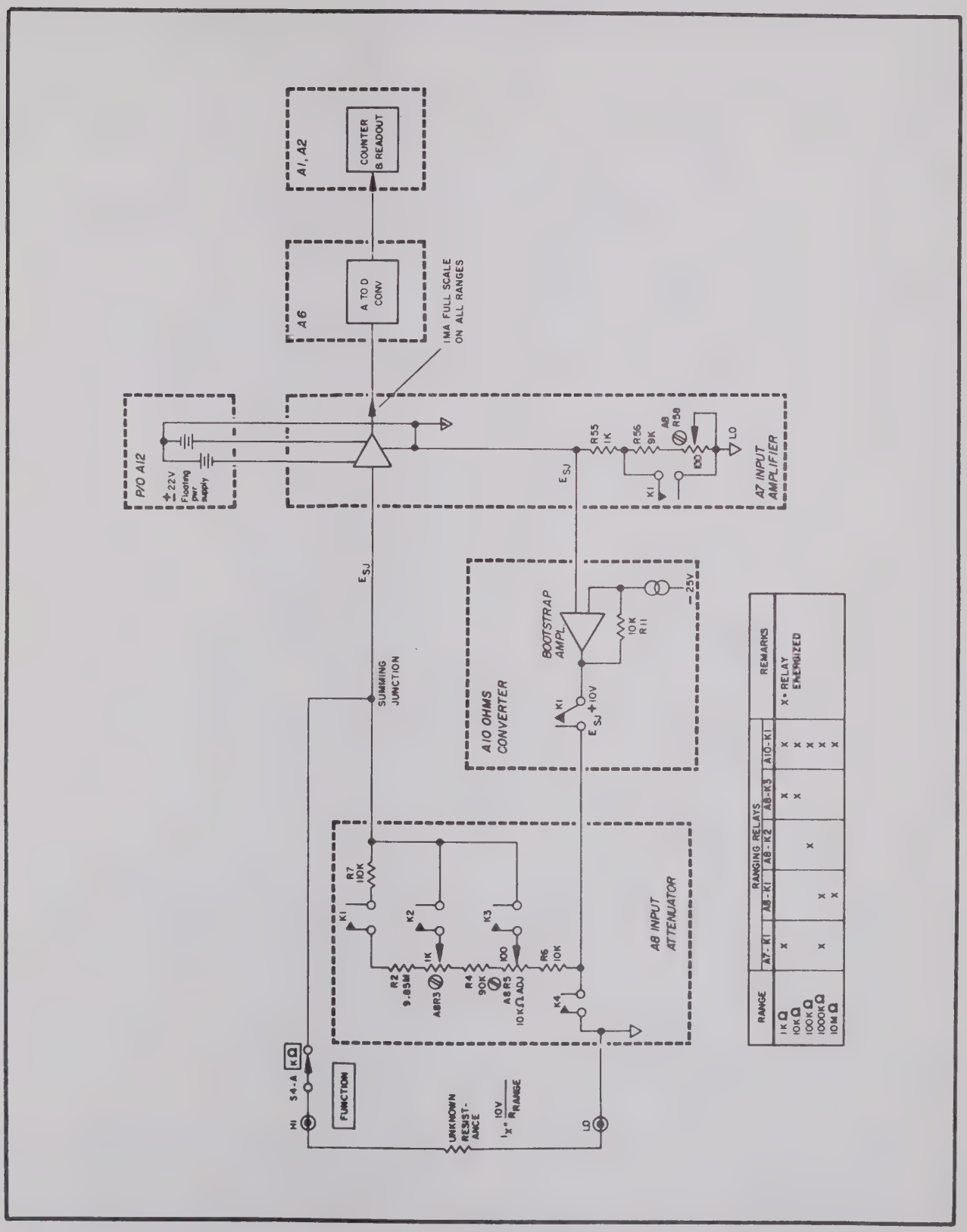


Figure 4-4. Resistance Measurement Circuit

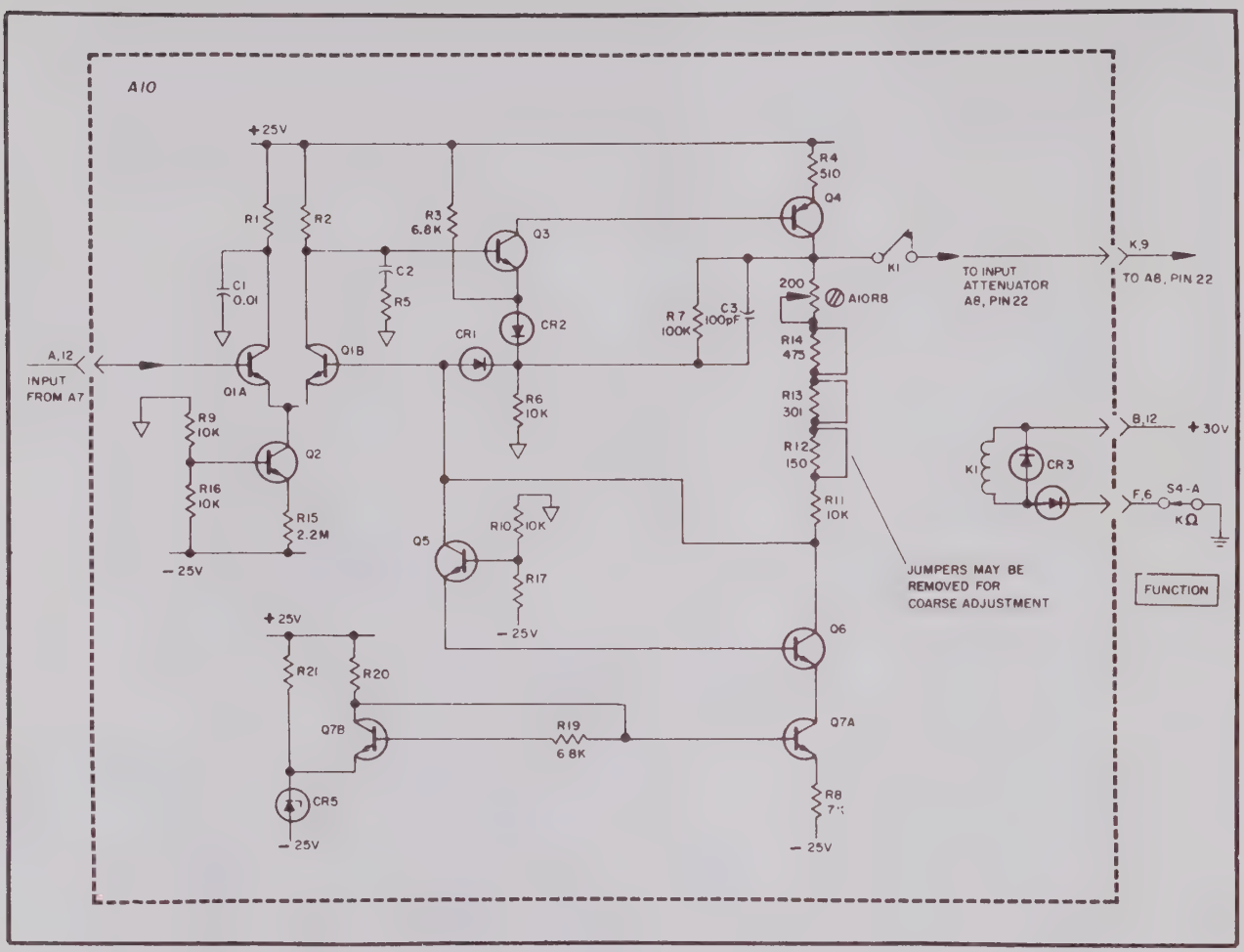


Figure 4-5. Ohms Converter

4-17. ACV MEASUREMENT

4-18. When the VAC function is selected, the ac input signal is converted to an equivalent dc voltage which is then measured by the dc circuitry previously described. The input is applied via an attenuator to the ac-to-dc converter which produces a dc level proportional to the average value of the applied ac. The instrument however, is calibrated so that the rms value of a pure sine wave is indicated at the readout.

4-19. AC-DC CONVERTER A9

4-20. The ac-dc converter consists of an input attenuator, a wideband amplifier with selectable negative feedback and an output filter network, as shown in figure 4-6. (Series capacitor A9-C1 blocks dc voltage so that only ac signals are measured. For waveforms containing both ac and dc, only the ac component is measured.) Relay A9K5 is closed for all ac volt ranges. Ranging relay operation is summarized in figure 4-6. For any given amplitude range, the input attenuator employs two parallel

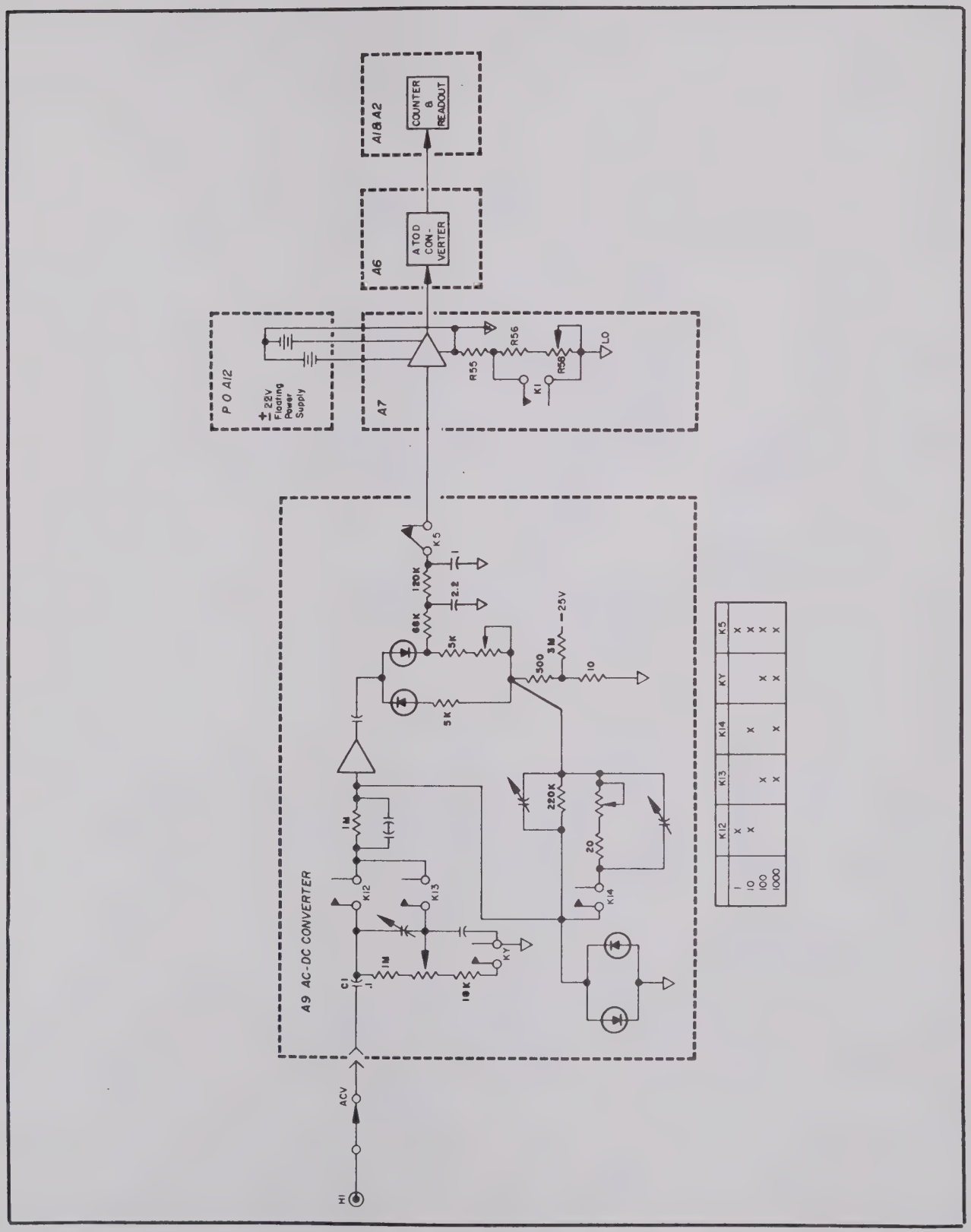


Figure 4-6. AC Voltage Measurement Circuit

RC networks to give a frequency-independent attenuation. The attenuated signal is amplified and half-wave rectified. The rectified ac wave is then filtered in the output RC filter network and applied to the input amplifier as a dc voltage.

4-21. DCMA MEASUREMENT

4-22. Direct current is measured by monitoring the voltage drop caused as the unknown current flows through precision shunt resistors mounted on A14. The voltage drop is monitored with the basic dc measuring circuitry. Figure 4-7 is a diagram of the DCMA measuring circuit. Relays A7K1 and A14K5 are energized by the function logic when the DCMA mode is selected at the front panel FUNCTION switch. The table in figure 4-6 summarizes the action of ranging relays. In each of the ranges, shunt resistances are selected to give a full scale input of 1 V to the dc circuit. The relay circuit connecting the shunts into circuit employs a 4-point Kelvin configuration with voltage sensing whereby the voltage drop across the shunt relay and associated wiring does not enter into the measurement to cause a readout error. This feature is especially significant when performing high current measurements. Diodes A14CR1 through A14CR8 form a clamp to protect the instrument from excessive voltages applied at the input.

4-23. JUMPER BOARD A11

4-24. A11 is a jumper board used in place of current shunt board A14 on instruments not containing the DCMA measurement option. Its purpose is to provide a connecting path from the LO INPUT terminal to the "LO out" connections on other pc boards.

4-25. TEST MODE

4-26. When TEST is selected on the front panel FUNCTION switch, the function logic energizes relay A8K5. With A8K5 closed, a path is provided from the variable voltage tap A8R9, TEST ADJ (see figure 4-8) to the input amplifier A7. A8CR1 gives a stable reference voltage of 6.6 volts. A8R9 is adjusted at the factory for a 1 V input to input amplifier A7. When the instrument is operating properly the resulting readout should be 0.1000 ±1 digit on the (1) range.

4-27. INPUT AMPLIFIER A7

4-28. The input amplifier is a high quality chopper-stabilized operational amplifier. It is connected to produce an output current proportional to its input voltage. This current output charges the integrating capacitor in the Analog-to-Digital (A-D) converter during the first half of the measurement cycle. (During the second

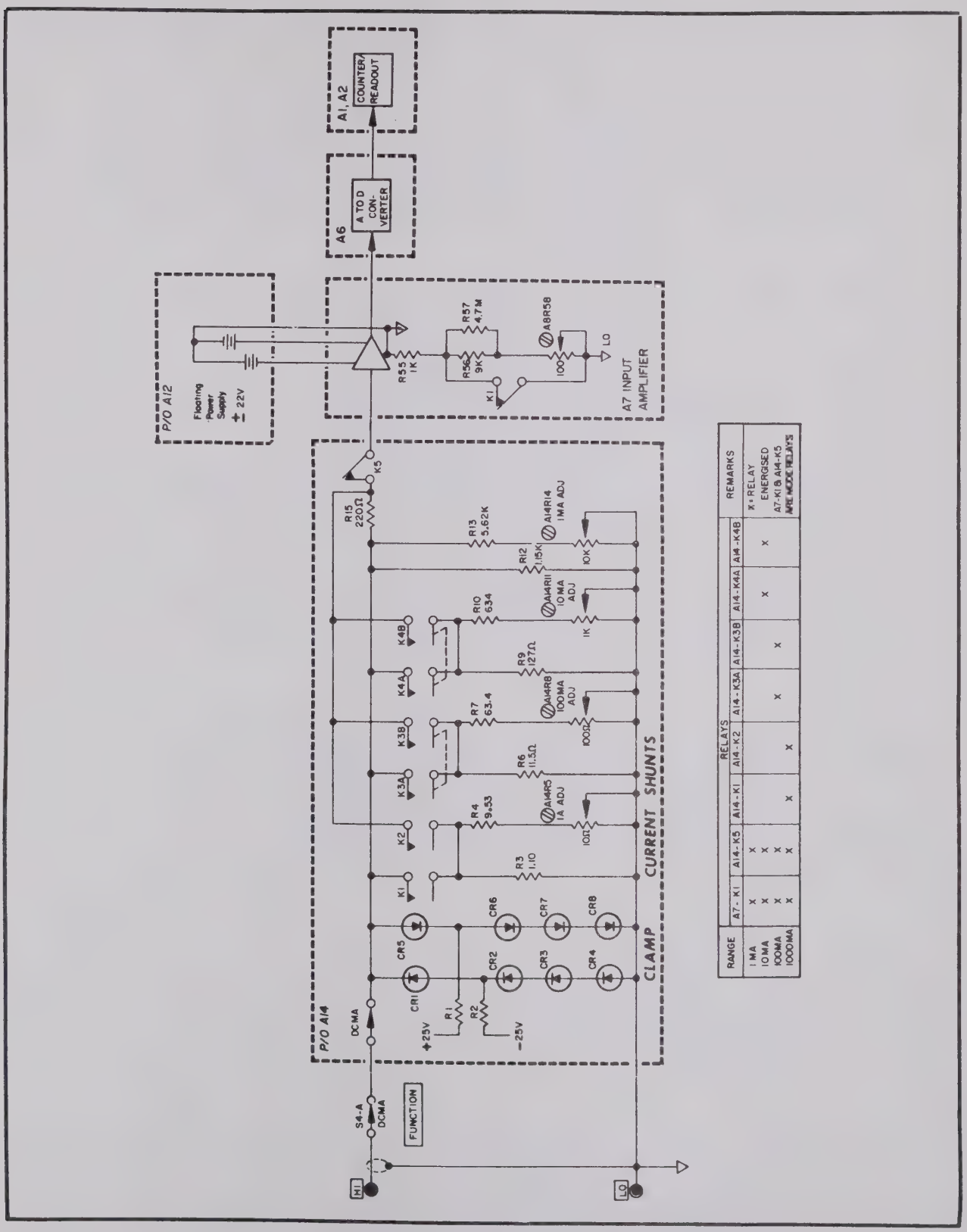


Figure 4-7. DC Current Measurement Circuit

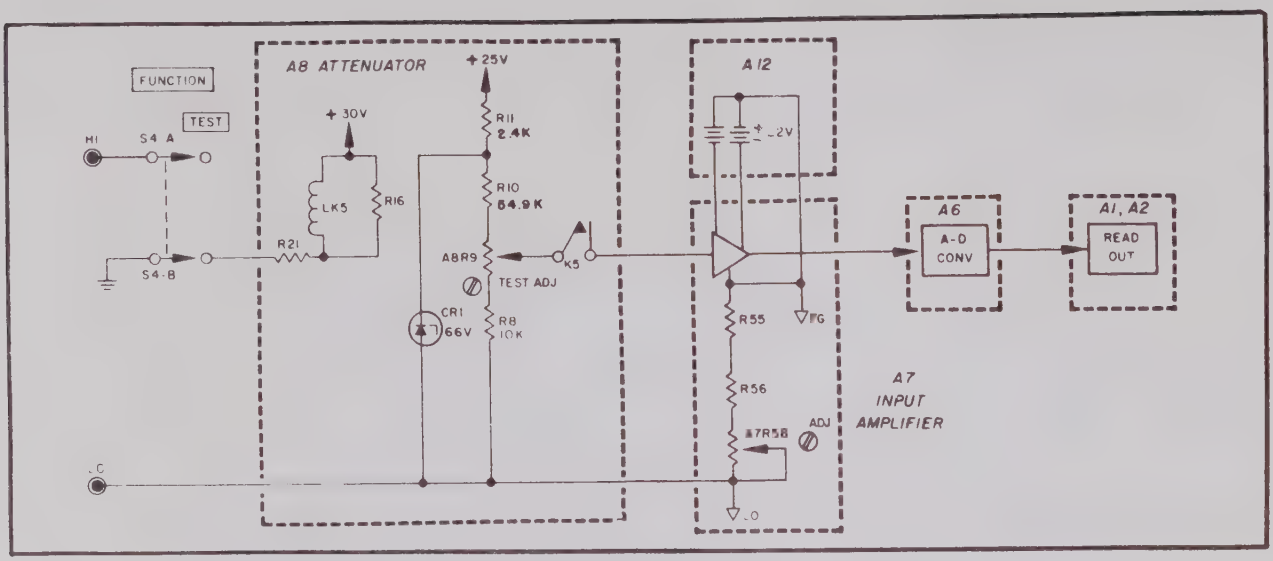


Figure 4-8. Self Check Circuit

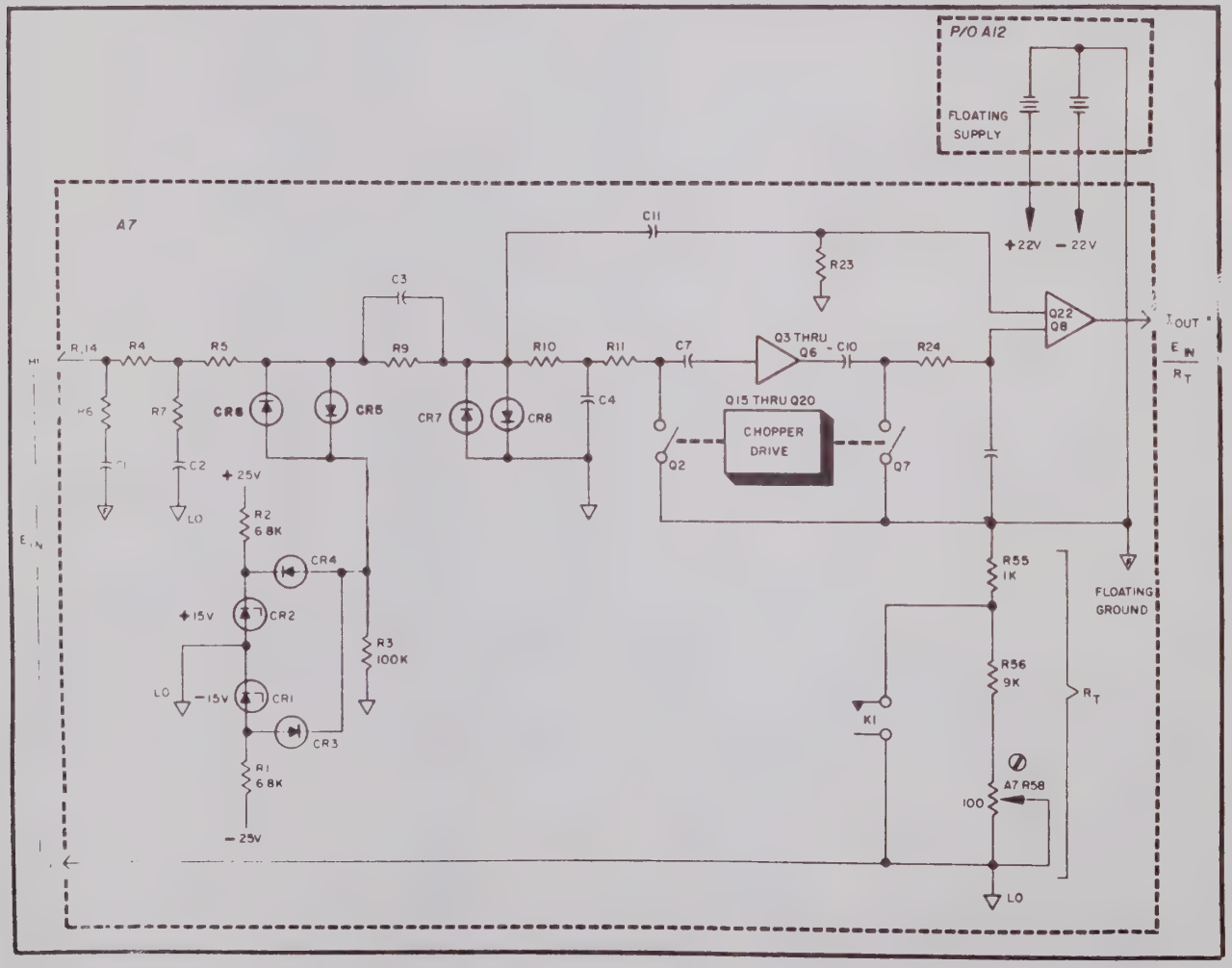


Figure 4-9. Input Amplifier

half of the measurement cycle, the output current is discharged from the integrating capacitor at a constant rate by the instrument's current reference source).

4-29. In operation, input to the amplifier (shown as E_{in} in figure 4-9) is either 1 V or 10 V full scale, depending upon the RANGE setting. The circuitry following the amplifier operates on a basis of 1 mA full scale for all ranges. The amplifier transconductance resistance R_T is selected by ranging relay A7K1 to equal 1 kΩ for a 1 V full scale input (A7K1 closed), or 10 kΩ for a 10 V full scale input (A7K1 open).

4-30. Frequencies above 3 Hz are fed into differential amplifier A7Q8/A7Q22 through high pass filter A7C11, A7R23. Frequencies below 3 Hz are applied directly to ac coupled amplifier A7Q3 where they are modulated, amplified, and demodulated. Chopper modulator A7Q2 is a MOS FET which is switched at a 250 Hz rate. The MOS FET is utilized because of its extremely high input impedance and wide temperature operating range. The input impedance of the amplifier is greater than 1000 megohms and this essentially is the input impedance of the Model 7000 for the two lowest ranges. The demodulated signal is fed into the positive gain input of the differential amplifier A7Q8, A7Q22. The 15 volt clamp in the input circuit of the amplifier protects it from damage due to overload. For small signal inputs the clamp has no effect on the amplifier input, because diodes CR3 and CR4 are reverse biased. For inputs with amplitude in excess of +15 V diodes CR5 and CR4 are forward biased and zener diode CR2 clamps the input to +15 V (plus the small voltage drop across CR5 and CR4). When the input signal becomes more negative than -15 V, diodes CR6 and CR3 are forward biased and zener diode CR1 clamps the input signal to -15 V. Resistor R3 provides a path for leakage current through CR4 and CR3 when they are reverse biased.

4-31. ANALOG-TO-DIGITAL CONVERTER A6

4-32. After the unknown signal has been converted to a dc current that is proportional to the magnitude of the unknown input voltage, it is fed to analog-to-digital converter, A6. This board contains a) sequence control logic including the start and reset circuits and b) dual slope integrating circuitry including the current rectifier, reference current generator, zero detector, and clock. These circuits are discussed in paragraphs 4-33 through 4-48.

4-33. START AND RESET CIRCUITS

4-34. The start circuit is a free-running multivibrator that produces pulses at a rate of 5 pps for all modes of operation except VAC; for VAC the rate is 1 pps. The leading edge of its output pulse (negative going) triggers the reset generator which in turn resets the counter to 00000. The trailing edge of the start pulse (positive going) sets the input flip-flop. A simplified schematic of the start and reset generator circuits is shown in figure 4-10

4-35. In operation, the pulse rate of the start circuit depends jointly on the RC time constant (set by A6C12, and A6R57/A6R72) and the reference voltage set by A6R70, A6R71. For all test modes except VAC, A6R57 and A6R72 are in parallel and give a sampling rate of approximately 5 pps; for the VAC test, the $\overline{\text{VAC}}$ input from the mode logic goes to ground and only A6R57 is in circuit. This changes the

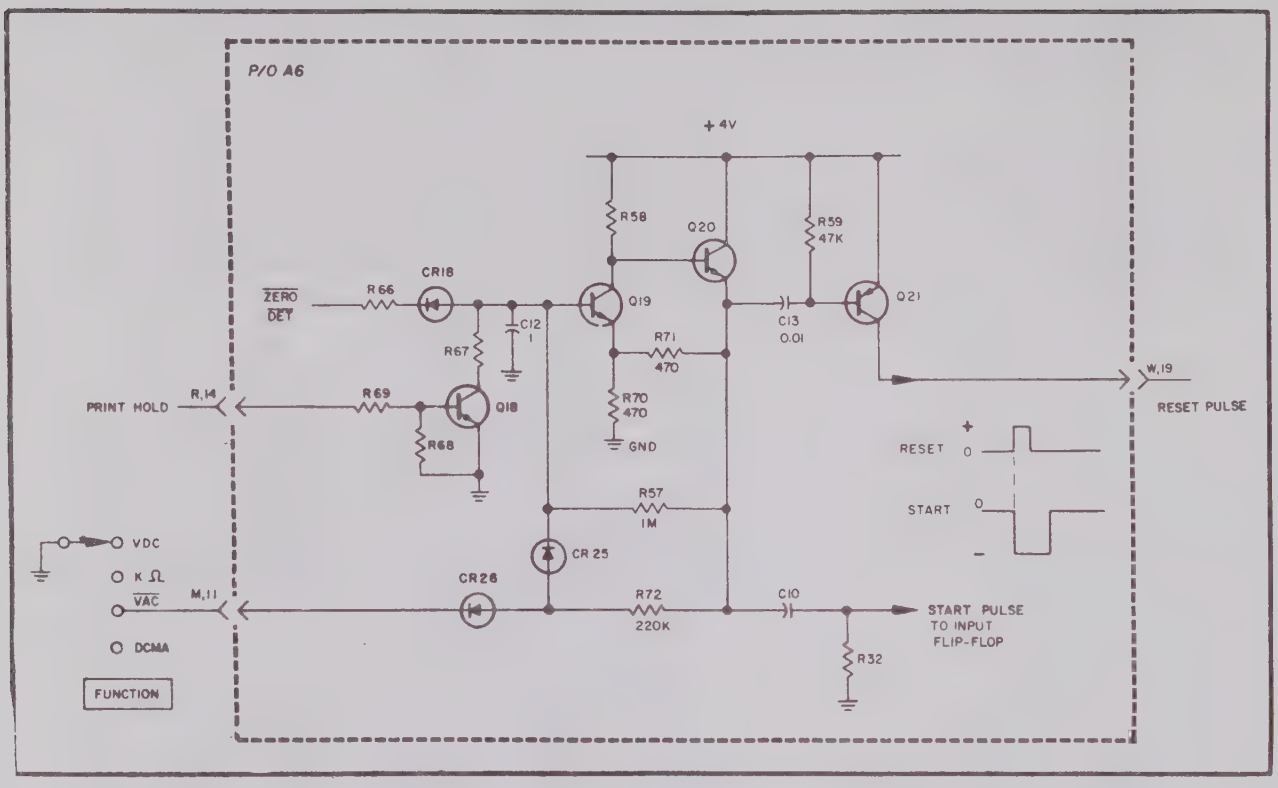


Figure 4-10. Start and Reset Circuits

sampling rate to 1 pps. The output waveform is created as follows: through regenerative coupling, A6Q19 is turned on and off alternately with A6Q20. When A6Q20 is on, the voltage at its emitter rises to +4 V and voltage divider A6R70, A6R71 puts 2 volts on the emitter of A6Q19, holding it off. Capacitor A6C12 now starts charging to +4 V through A6R57. As the voltage across A6C12 becomes larger (approximately 2.5 V), A6Q19 is turned on, turning A6Q20 off. The emitter of A6Q20 goes low causing A6C12 to discharge through A6R57. The charge on A6C12 eventually falls too low to keep A6Q19 turned on; so A6Q19 is turned off and the cycle is repeated at a rate of 5 pulses per second. The input to the base of A6Q19 from the zero detector prevents A6C12 from charging during the time that the measurement cycle is taking place. The sample rate is thus timed from the moment that the zero detector reaches null and a readout is presented.

4-36. The reset pulse is generated by A6Q21. This transistor is normally off until triggered by the leading edge of the start pulse. At this time it generates a short positive pulse which resets the instrument circuits prior to the start of the measurement cycle (and of start pulse).

4-37. The "PRINT HOLD" circuit is provided for use with external equipment. Solid state switch A6Q18 can be turned on by an external source. When this occurs, the voltage across A6C12 is clamped to ground and the start circuit is inhibited.

4-38. CURRENT RECTIFIER

4-39. The output signal from the input amplifier is applied to a current rectifying circuit located on assembly A6. The purpose of the rectifier is to maintain the linear relationship to the input current generated by the amplifier (full scale = 1 mA), but with a constant negative polarity regardless of the polarity of the signal being measured. Refer to figure 4-11. For negative currents, $I_{in} = I_{out}$ through CR2. For positive currents, the signal is routed through CR1 into A6R33. This creates a voltage drop of $V_{R33} = I_{in}R33$. Negative feedback makes the voltage across A6R34: $V_{R34} = -V_{R33} = -I_{in}R33$. The current in A6R34 is the current drained from the integrating capacitor. Therefore:

$$I_{out} = - \frac{V_{R34}}{R_{34}}$$

4-40. Figure 4-12 is a simplified schematic of the current rectifier. Transistor A6Q1 is a differential stage with A6Q2 connected as a constant current source. The output signal at the collector A6Q1B is coupled to the base of emitter follower A6Q3. The output from A6Q3 is coupled to the input of driver stage A6Q4. Feedback is via A6R33 and A6R34. Diode A6CR5 and transistor A6Q5 provide the signal controlling the (+), (-) polarity readout. When the input signal is negative (-), diode A6CR5 is non-conducting and A6Q5 is turned on.

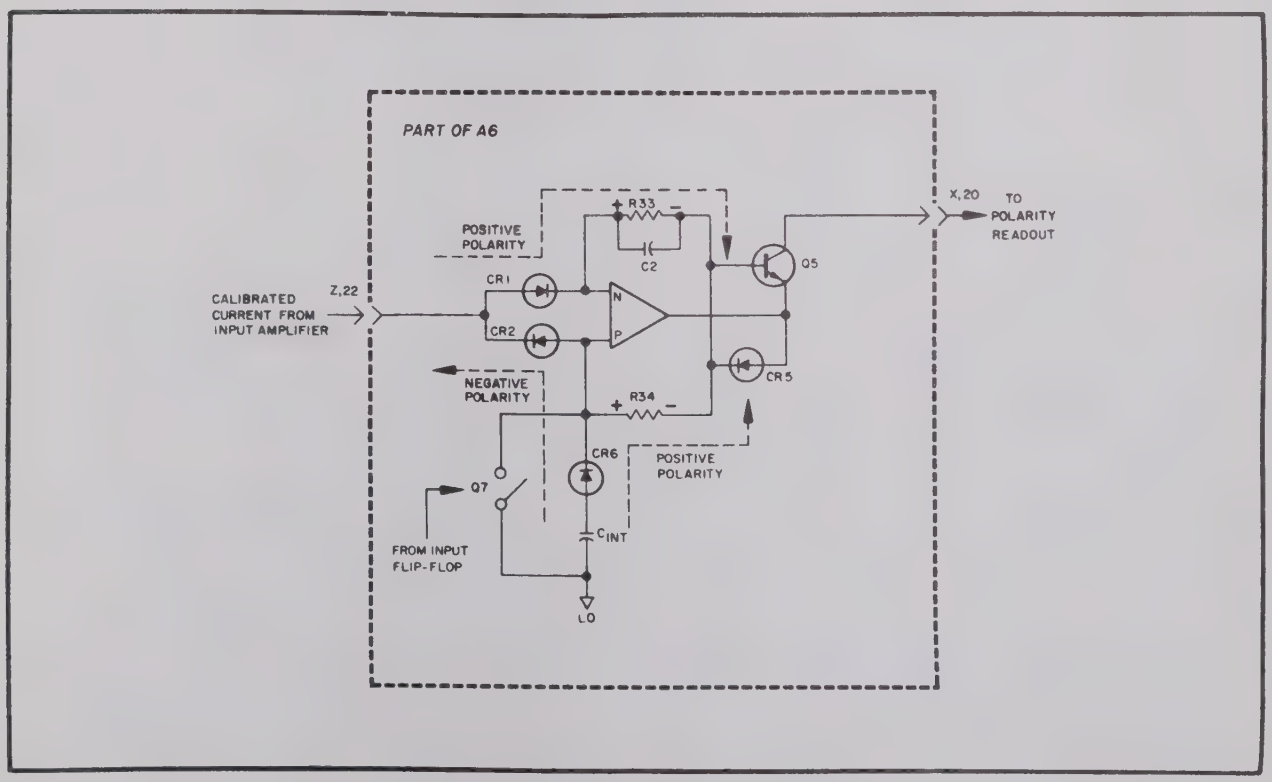


Figure 4-11. Block Diagram, Current Rectifier

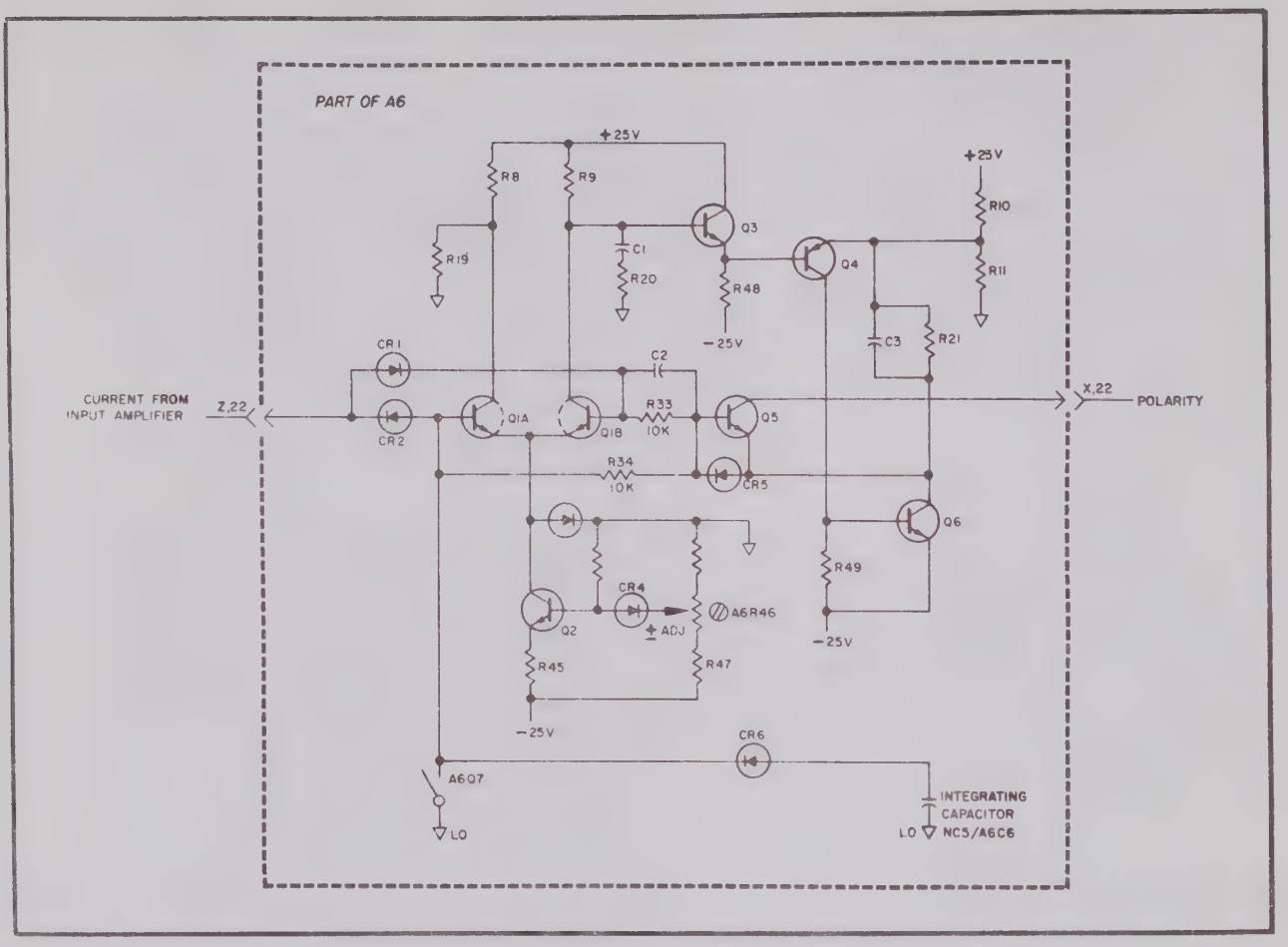


Figure 4-12. Schematic, Current Rectifier

4-41. REFERENCE CURRENT GENERATOR

4-42. The reference generator supplies a positive current of 1 mA to the integrating capacitor during the second half of the measurement cycle. Figure 4-13 shows a simplified schematic of the generator. Zener diode A6CR11 produces a 6.6 V offset between differential amplifier A6Q9A/B. The differential amplifier, in an effort to adjust for zero volts across its two inputs, drops 6.6 V across resistors A6R12, A6R22, A6R23, A6R24, A6R25. By selecting a series value of 6.6 kΩ with these resistors, a full scale current of 1 mA is generated. The short circuits across A6R22 - A6R24 can be removed for coarse current adjustment and the output current can be adjusted to exactly 1 mA by potentiometer A6R12 (F.S. ADJ.). Zener diode A6CR15 acts as a stable reference for A6Q11 which is a current source for the differential amplifier. Transistor A6Q10 is a solid state switch used to direct the path of the generator current. During the first half of the measurement cycle, A6Q10 is held off by the "IN" signal from the input flip-flop, and current drains through A6CR8, A6CR9, A6R50 . When full scale is reached the input flip-flop changes state allowing A6Q10 to turn on. Current from the reference generator then recharges the integrating capacitor to zero volts. At that time the $\overline{\text{ZERO}}$ $\overline{\text{DET}}$ signal goes high and A6Q10 is turned off again.

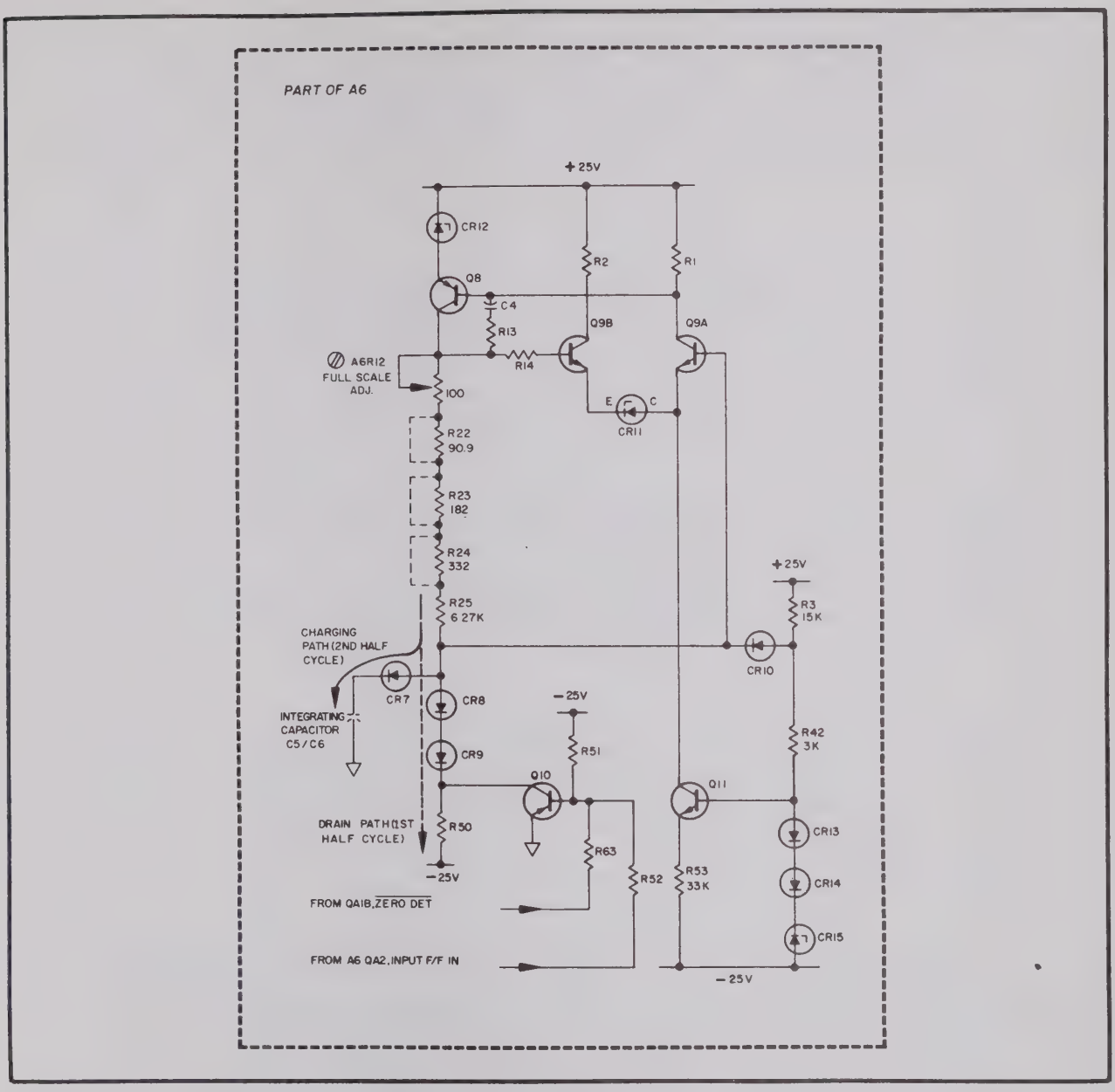


Figure 4-13. Reference Current Generator

4-43. ZERO DETECTOR

4-44. The zero detector controls operation of the clock oscillator that drives the readout counter. It allows clock pulses to reach the counter from the start of the measurement cycle until the end of the second half of the measurement cycle when the integrating capacitor has been discharged back to the zero level. See timing diagram on figure 4-2.

4-45. At the start of a measurement cycle, the detector is triggered by the input flip-flop and enables the clock. The clock remains enabled until the charge on the integrating capacitor returns to zero.

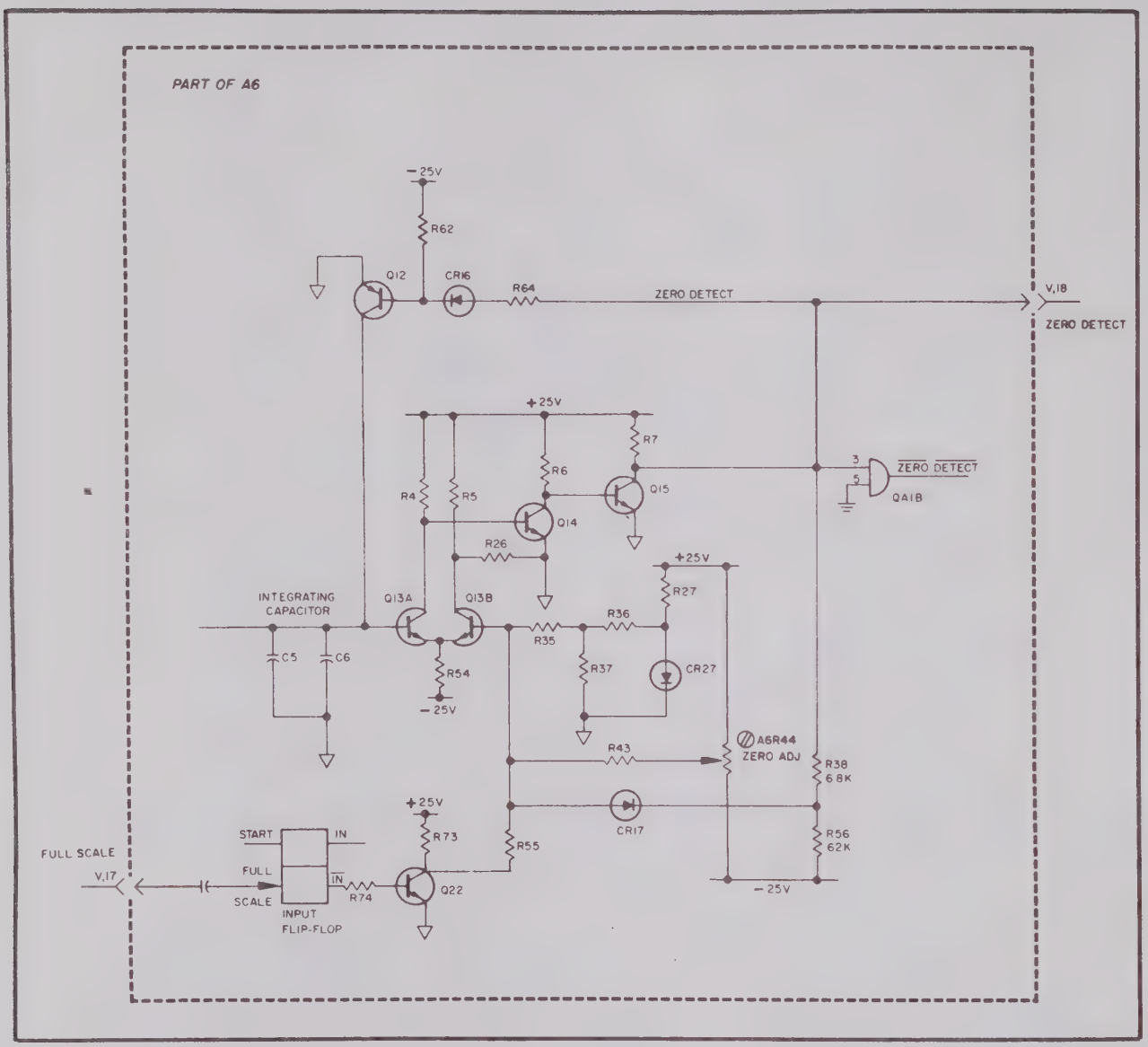


Figure 4-14. Zero Detector

At this time the zero detector disables the clock until the start of the next measurement cycle. Figure 4-14 shows a simplified schematic of the detector circuit. The integrating capacitor is connected to the inverting input of differential amplifier A6Q13, and the output of the input flip-flop is connected via a voltage divider network to the non-inverting input. Diode A6CR17 provides a feedback path between the amplifier output and the non-inverting input. At the start of a measurement cycle the flip-flop "$\overline{IN}$" output goes low and turns A6Q22 off, allowing the voltage at the base of A6Q13B to go high and drive amplifier A6Q13A/B. The voltage level at the collector of A6Q13B goes low while the collector voltage of A6Q13A goes high. The resulting bias voltage across the base-emitter junction of A6Q14 turns it on, and A6Q15 is turned off. Diode A6CR17 is reverse biased at this time by the positive voltage on the collector A6Q15. When the counter reaches full scale, a full scale pulse is generated which resets the input flip-flop causing its "$\overline{IN}$" output to go high. However, the charge on

the integrating capacitor is now at its maximum negative value and this keeps the amplifier locked in the state which holds A6Q15 off. As the charge on A6C5/A6C6 decreases, (becomes less negative) differential amplifier A6Q13A/B eventually allows A6Q15 to conduct. The negative collector voltage of A6Q15 now is applied to the base of A6Q13A/B and locks the zero detector in this state until zero crossover occurs.

4-46. CLOCK

4-47. The clock is a gated free running multivibrator that includes A6Q16 and A6Q17, as shown in figure 4-15. At the start of a measurement cycle, the ZERO DET signal triggers the clock. The clock then sends pulses to the counters until the charge on the integrating capacitor has gone through its excursion and returned to zero. At this time, the zero detector inhibits the clock. The clock remains inhibited until the start of the next measurement cycle.

4-48. During its operation, the clock output is taken from the collector of A6Q17 and applied through "AND" gate A6QA1A to the input of the first decade counter. When the voltage at the collector of A6Q17 goes high, the voltage at pin 7 of A6QA1A goes low; when A6Q17 collector voltage goes low, the voltage at pin 7 goes to +4 volts. Thus the clock output is a series of positive pulses occuring at a rate of 250 kHz.

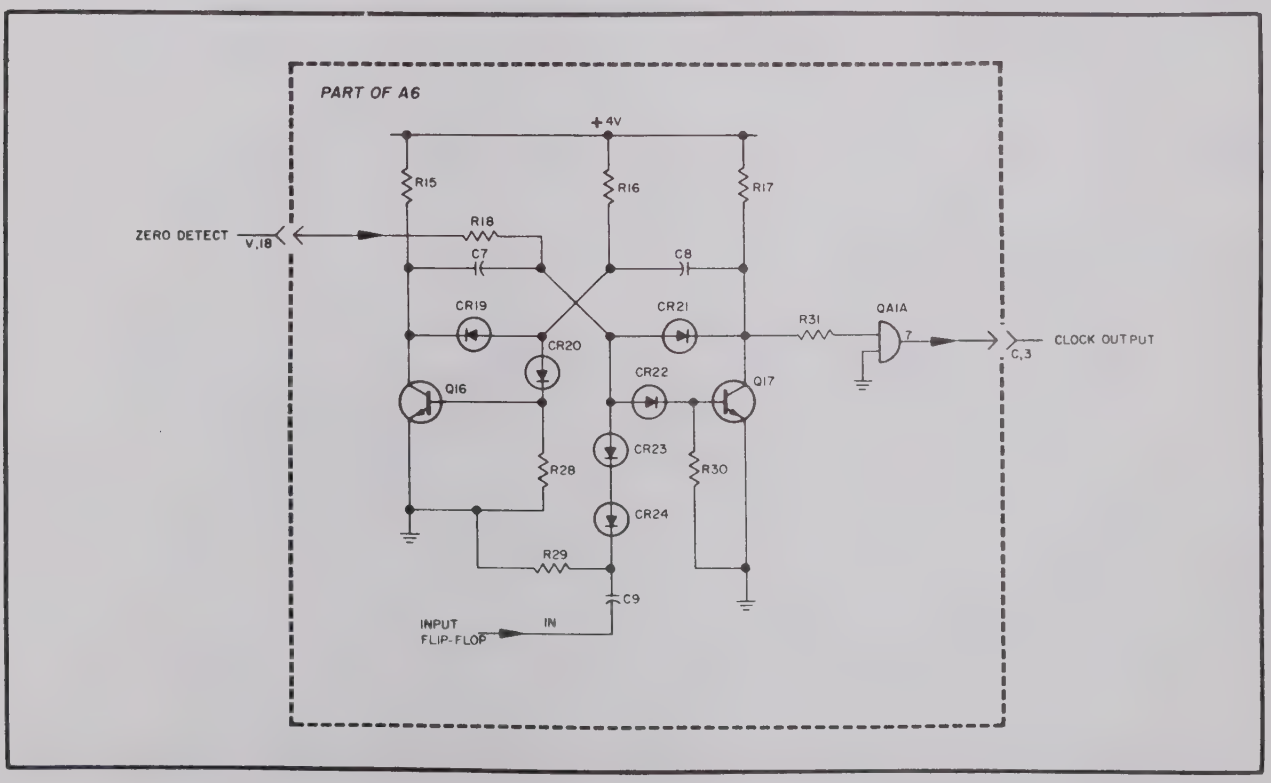


Figure 4-15. Clock

4-49. DECADE COUNTER AND COUNT READOUT A1/A2

4-50. The decade counter consists of four identical cascaded 958 CμL elements. (The units stage of the counter and readout assemblies is shown in figure 4-16). It is typical of all four stages. Each of these elements consists of four cascaded binary flip-flops modified by a feedback loop to count in 1-2-4-8 binary-coded-decimal. The output pulses from the clock oscillator are fed to the first of the four cascaded counting elements and the counter accumulates the number of pulses received. Outputs (in the form of negative voltage steps) from each of the counting elements are coupled to the inputs of a 959 μL buffer/storage unit allows the state of the counter output stage to be sampled and held for a controlled amount of time. In addition, it provides both true and complement signals; the true signal is presented to a 960 CμL decimal decoder/driver, while its complementary signal is utilized as an output to the BCD circuitry.

4-51. The 960 CμL decoder/driver accepts 1-2-4-8 BCD inputs at integrated circuit levels and produces 10 mutually exclusive outputs that directly control the ionizing potentials of a gas-filled, cold cathode indicator tube. A number -- 0 through 9 -- is presented at each readout tube in accordance with the count recorded in that particular stage.

4-52. Besides clock pulses, other circuit inputs to the counter are: a reset pulse from the measurement start circuitry on board A6, and a gate pulse generated in the zero detector on board A6. At the start of a measurement sequence, the reset pulse sets the counter to 00000. During the first half of the conversion cycle clock pulses drive the counter to 10000 and overspill (00000); during the second half, the counter advances from 00000 until the zero detector inhibits the clock, stopping the count. The signal occuring at overspill, called the FULL SCALE pulse, is fed back to the analog-to-digital circuitry and causes

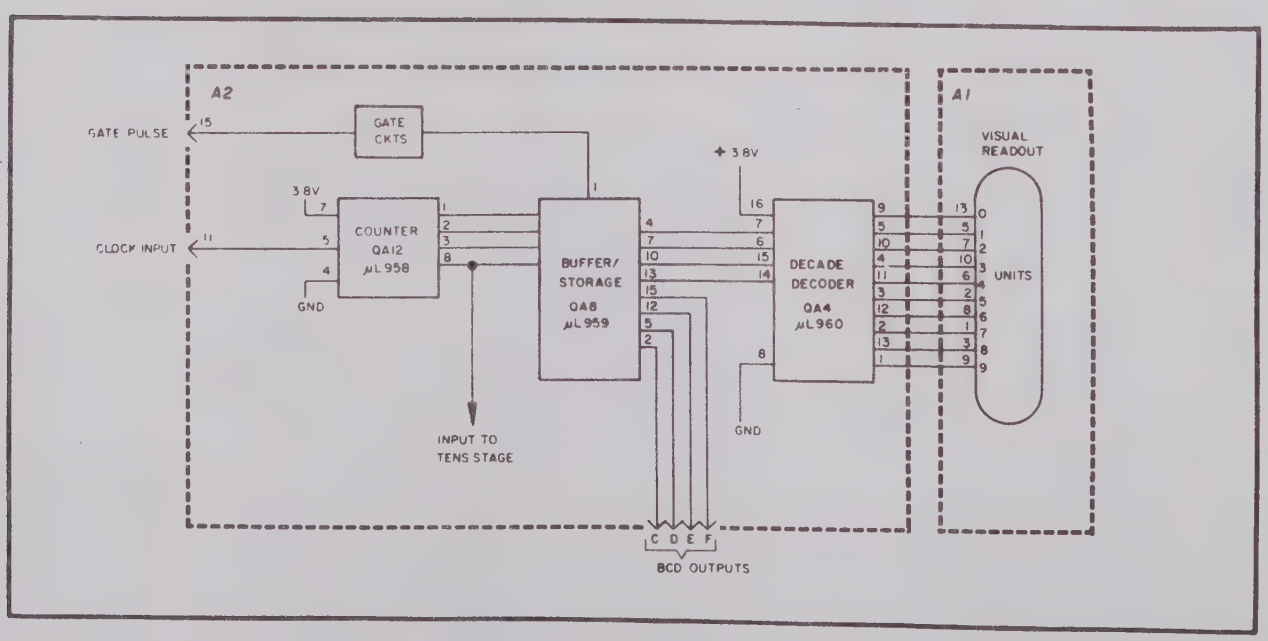


Figure 4-16. Counter and Readout - Units Stage

the changeover from one-half of the measurement cycle to the other. The number stored in the counter when the clock pulses stop is the test result. The gate pulse generated at this time changes the readout to the new count information stored in the buffer/storage elements.

4-53. OVERRANGE DIGIT

4-54. The most significant digit counter differs from the decade counters in that it can have only one of two states, either a "1" or a "0" (binary counter). When the measurement cycle begins, the counter is reset to 00000. When 10000 pulses have entered the counter, the binary counter changes state back to "0", and in doing so generates the full scale pulse. This full scale pulse resets the input flip-flop as described previously.

4-55. DECIMAL READOUT

4-56. Within the counter and readout circuitry (on board A2) are four transistors that are used as decimal point drivers. A typical decimal point circuit is shown in figure 4-17. When a range is selected, the decimal point driver for that range is turned on and its low going collector voltage causes the corresponding decimal point indicator to light. Four such drivers indicate all possible readout ranges of the instrument as: XXXXX, XXXX.X, XXX.XX, XX.XXX, and X.XXXX.

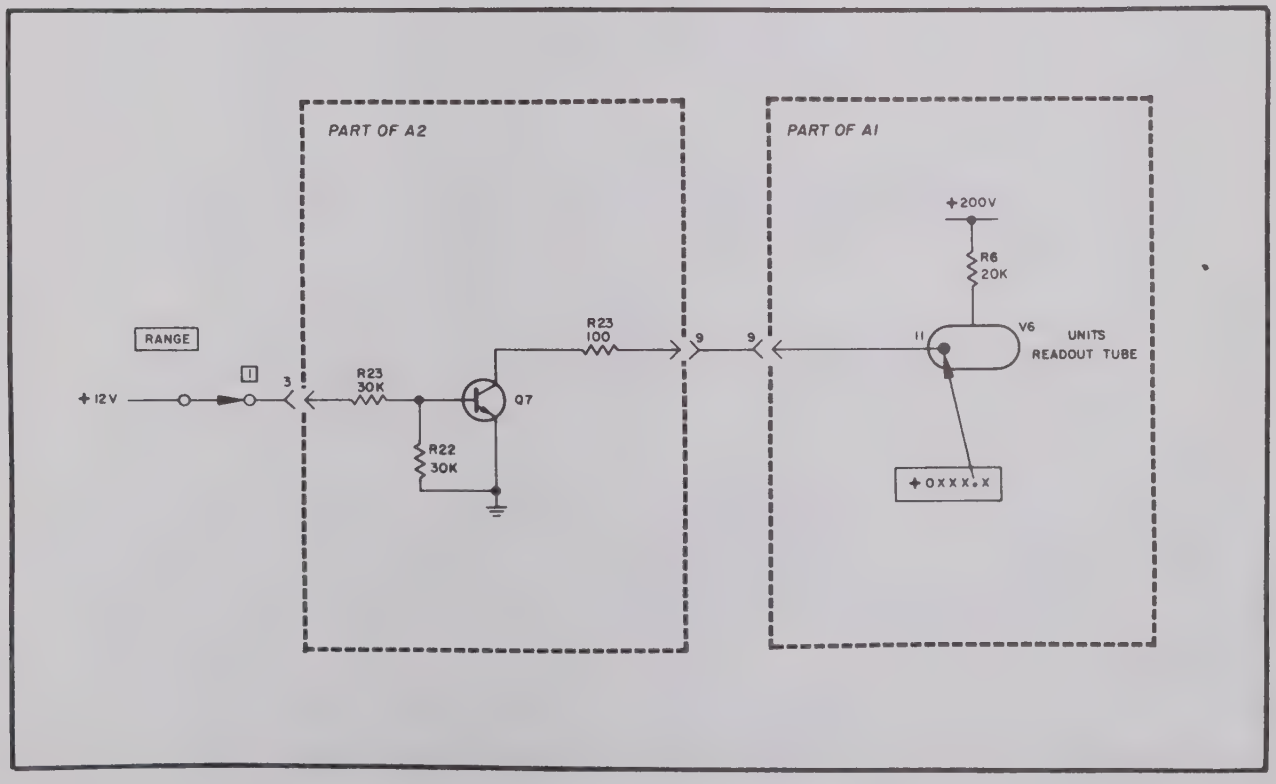


Figure 4-17. Typical Decimal Point Circuit

4-57. POLARITY INDICATION

4-58. The polarity indicating circuit (shown in figure 4-18) is operational for DCV and DCMA modes only. (For the other three modes no polarity indication is necessary.) When either DCV or DCMA is selected, diode A2CR6 or A2CR7 conducts, shunting current away from the base of A2Q3, turning this transistor off. With A2Q3 turned off, diodes A2CR1 and A2CR3 are reverse biased, and polarity transistors A2Q1 and A2Q2 are enabled. When functions other than DCV or DCMA are selected, A2Q3 conducts and forces A2Q1 and A2Q2 to remain off, inhibiting the polarity indicator. Polarity information from the current rectifier circuit is provided only when positive polarity input signals are sensed. In the absence of a positive polarity information from the current rectifier, negative polarity indication is automatically presented. With no input signal, A2Q2 is held on by the positive current on its base

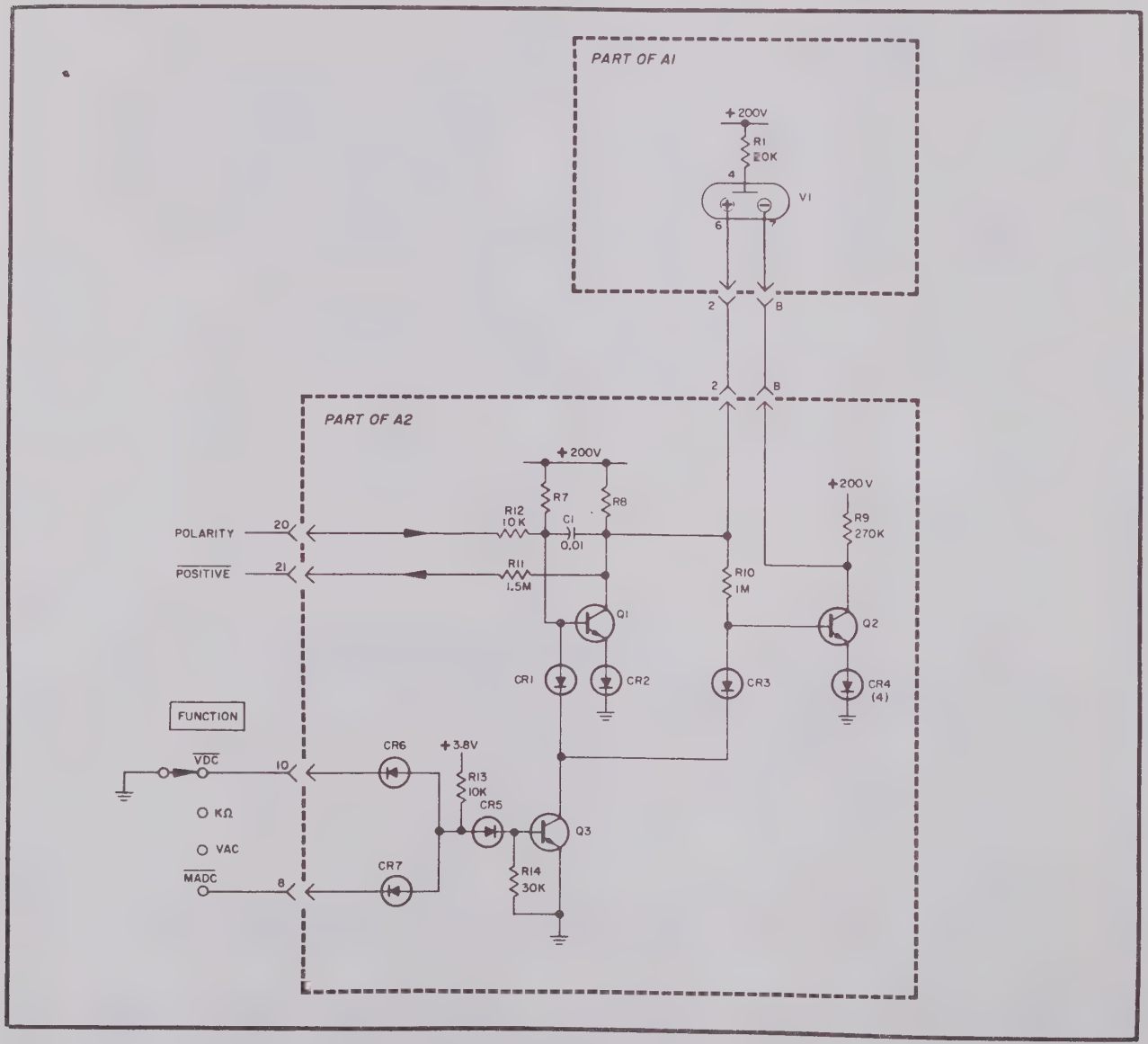


Figure 4-18. Polarity Indicator

delivered from the +200 V source through A2R8 and A2R10. When A2Q2 is turned on, its collector voltage causes the cathode of (-) POLARITY indicator to go low. A potential difference of approximately 200 V then exists between the lamp's cathode and anode so that the lamp conducts and negative polarity indication is given.

4-59. When input signals of positive polarity are measured with the Model 7000, A6Q5 (which is part of the current rectifier circuit) conducts and A2Q1 is turned on. The collector of A2Q1 then goes low, pulling the cathode of the (+) POLARITY indicator low. As a result of the 200 V potential between (+) POLARITY cathode and lamp anode, the (+) sign is illuminated. Simultaneously, a negative voltage step is applied to the BCD circuit for external data logging.

4-60. AUTOMATIC RANGING (OPTION 01)

4-61. Instrument ranging can be automatic on all measurement modes of operation when the autoranging plug-in board is added. The ranging process occurs only when the input signal changes in amplitude and falls outside the prescribed limits of the range in use. These limits are 12000 or 00980. The instrument ranges up or down, according to the direction of the level change, until the correct range is found. In the absence of an input, the meter drops to the lowest range. Basic range data is generated by a reversible ring counter with five output lines, each corresponding to a range. (A ring counter is a loop of interconnected elements, any one of which is in a specified state at any one time. Each time an input pulse is applied, the specified state advances one position in an ordered sequence around the loop. A reversible counter has two inputs - one moves the ordered sequence in one direction around the loop; the other moves it in the opposite direction.) The two inputs to the ring counter, designated up range and down range, are derived from logic that compares the system counter output with operation of the null detector. In brief this circuit:

a. produces an up range pulse when the zero detector does not reach null before the counter reaches 12000. (This is also a range overload condition and is detected by the overload logic.)

b. produces a down range pulse when the zero detector reaches null before the readout exceeds 00980. This is a range condition where the readout can be given with better resolution on a lower range.

4-62. Figure 4-19 shows the logic circuitry controlling the functions described above and figures 4-20A 4-20B show circuit timing. Each time the counter reaches 12000, the JK complementing flip-flop element A4QA3 is triggered. The output at pin 5 is coupled to AND gate A4QA2B. The second input to A4QA2B is $\overline{\text{ZERO}}$ $\overline{\text{DET}}$. If this signal goes high before 12000 (range correct), no pulse output is produced. However, if $\overline{\text{ZERO}}$ $\overline{\text{DET}}$ goes high after 12000 (range incorrect), a positive uprange pulse is generated at 12000 when the signal at pin 5 of the JK flip-flop goes low. The dotted lines at the right of figure 4- 20A show instrument in the correct range; the solid lines indicate production of an uprange pulse.

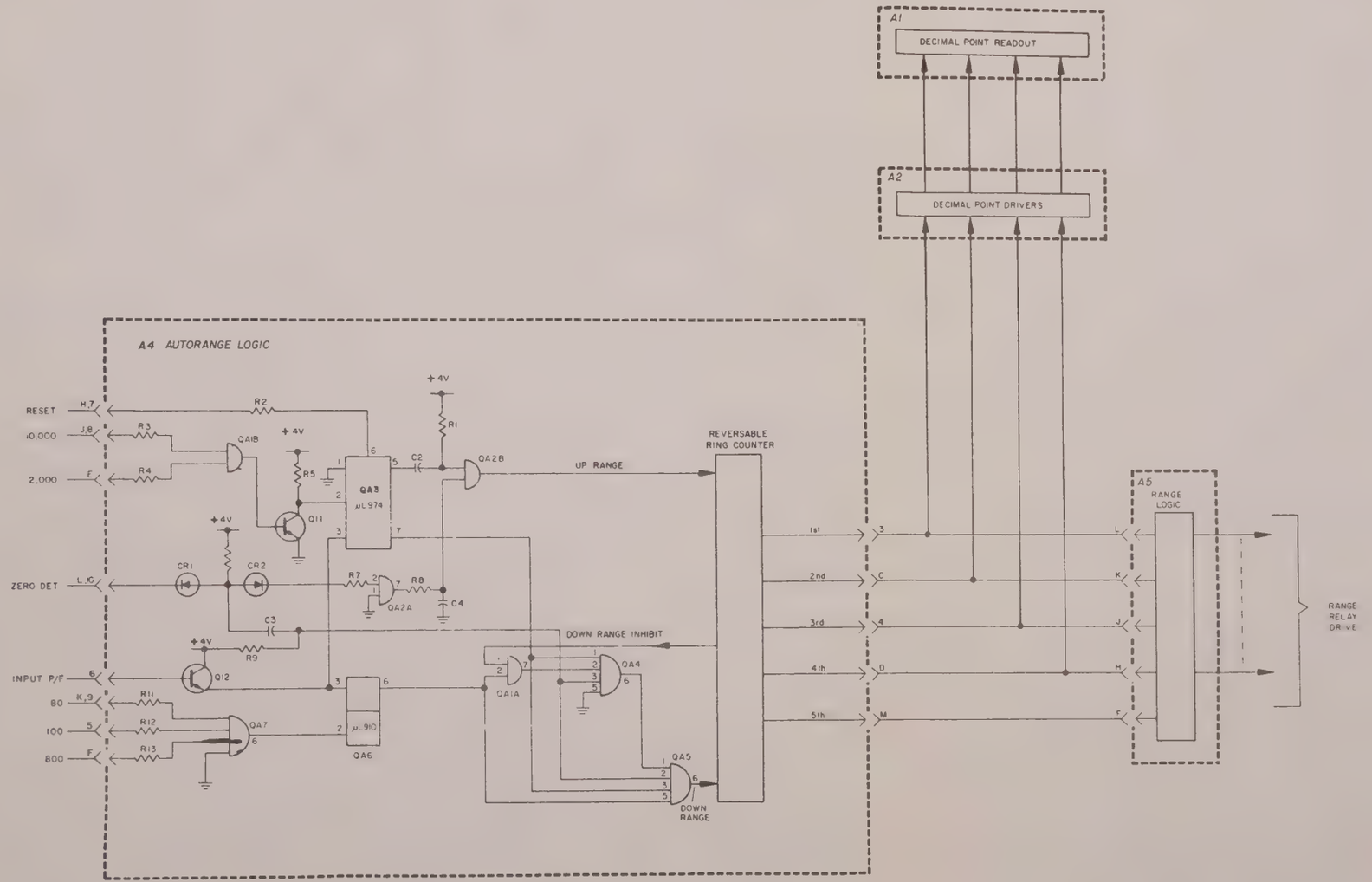


Figure 4-19. Auto Range Logic

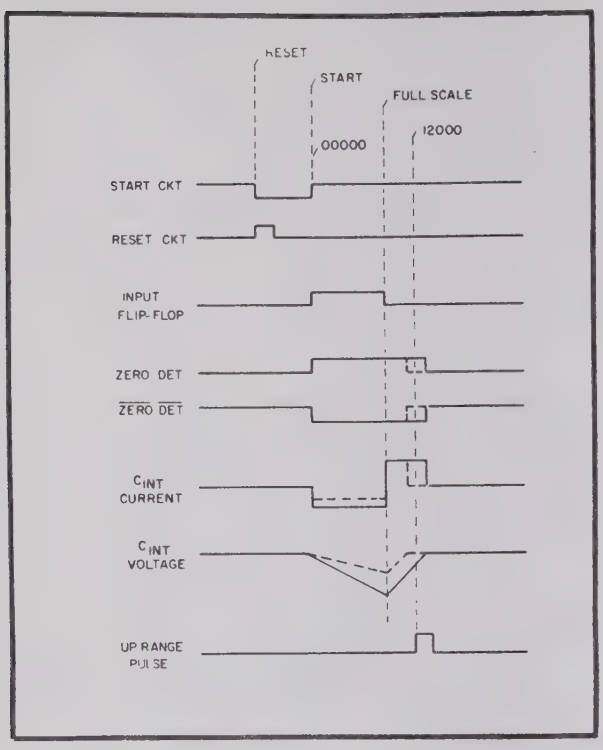


Figure 4-20 A. Timing Up-Range Pulse

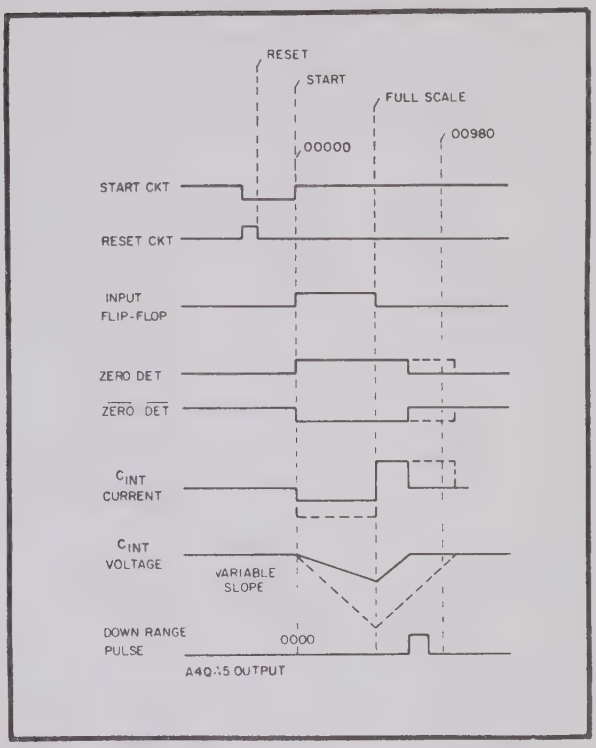


Figure 4-20 B. Timing Down-Range Pulse

4-63. Generation of the downrange pulse is derived from AND gate A4QA5. AND gate A4QA5 compares the output of flip-flop A4QA6A/B and the ZERO DET signal. Output of the flip-flop is low from full scale to 00980 and if null is detected during this time a downrange pulse is generated. The absence of a ZERO DET signal during the same period prevents generation of the downrange pulse. When the instrument is on the lowest range the collector voltage at A4Q1 is fed into A4QA1A and inhibits downranging. The dotted lines in figure 4-20B show circuit operation when the downrange is not produced; the solid lines show production of the pulse.

4-64. RING COUNTER

4-65. Operation of the ring counter is such that at any one time all of the stages in the counter are on except one; it is held off. Assume an initial condition with A4Q3 off (refer to figure 4-21). In this condition, decimal point driver A4Q8 is turned on and the visual range indication is given as XXX.XX. The positive voltage at the collector of A4Q3 deposits a charge on A4C70 and A4C10. A4C70 is used in upranging; A4C10 in downranging. The collectors of transistors A4Q1, A4Q2, A4Q4, and A4Q5 are held to ground when A4Q3 is off.

4-66. When an uprange pulse (the negative going trailing edge is used to trigger the counter) is applied to the ring counter, the negative pulse is passed by steering diodes A4CR3, A4CR4, A4CR5, A4CR6 and transmitted across the input capacitors to the bases of their respective transistors. Momentarily all of the stages are driven off. Due to the preset charge on A4C70, A4Q4 is driven further off than the other stages. A4Q3 is driven on as the voltage rise at the collector of A4Q4 is transmitted via A4CR17

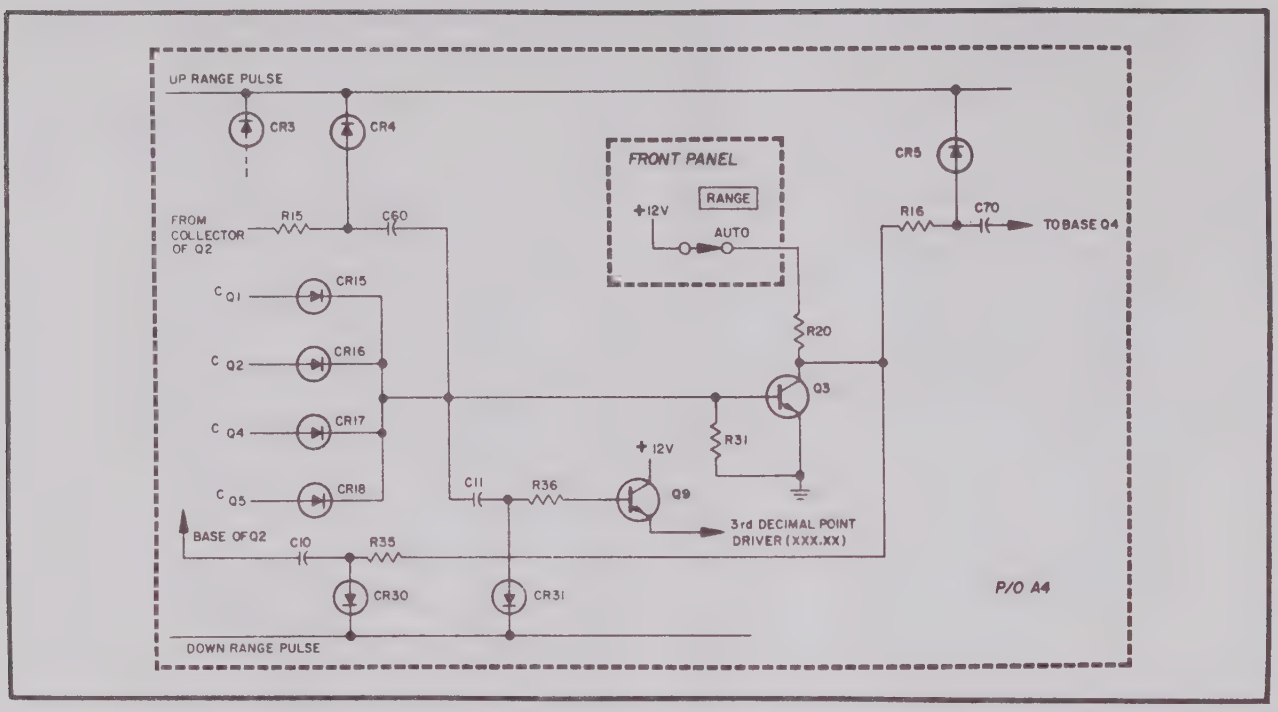


Figure 4-21. Ring Counter, Third Stage

to the base of A4Q3. Similar action also holds all of the other stages on. The new decimal point location is XXXX.X.

4-67. POWER SUPPLIES A12

4-68. Power supplies in the Model 7000 are mounted on board A12. Supply voltages are +30 V, 12 V, ±25 V, +4 V, and ±22 V (floating).

4-69. FLOATING SUPPLY

4-70. The floating ±22 V supply is used with the input amplifier exclusively. The ground reference of this supply is isolated from the main circuit common (LO). Regulation of the -22 V supply is controlled by series regulator A12Q19. See figure 4-22. Reference is established by zener diode A12CR10. The -22 V output is sensed across resistors A12R40 through A12R43, and output variation is detected at the base of A12Q18. The emitter of A12Q18 is held at a fixed reference potential by zener diode A12CR10. The output at the collector of A12Q18 controls series regulator A12Q19. Regulation is accomplished as follows: an increase in current load causes a tendency to lower output voltage. The slight voltage drop is sensed at the base of A12Q18 which conducts less . This allows the voltage at the base of A12Q19. The series regulator then conducts harder and compensates for the voltage drop. A12R33 shares load current with series regulator A12Q19. Transistor A12Q20 and resistor A12R39 act together to provide short circuit protection. Output current flows through A12R39 and when current becomes too large, the drop across A12R39 is sufficient to turn A12Q20 on. The series regulator is turned off. Capacitor A12C8 is an output filter that reduces ripple at the output of the supply. A12R32 and A12CR11 provide a load path for A12Q18. A12C6 is a filter capacitor which reduces ripple at the input to the power supply.

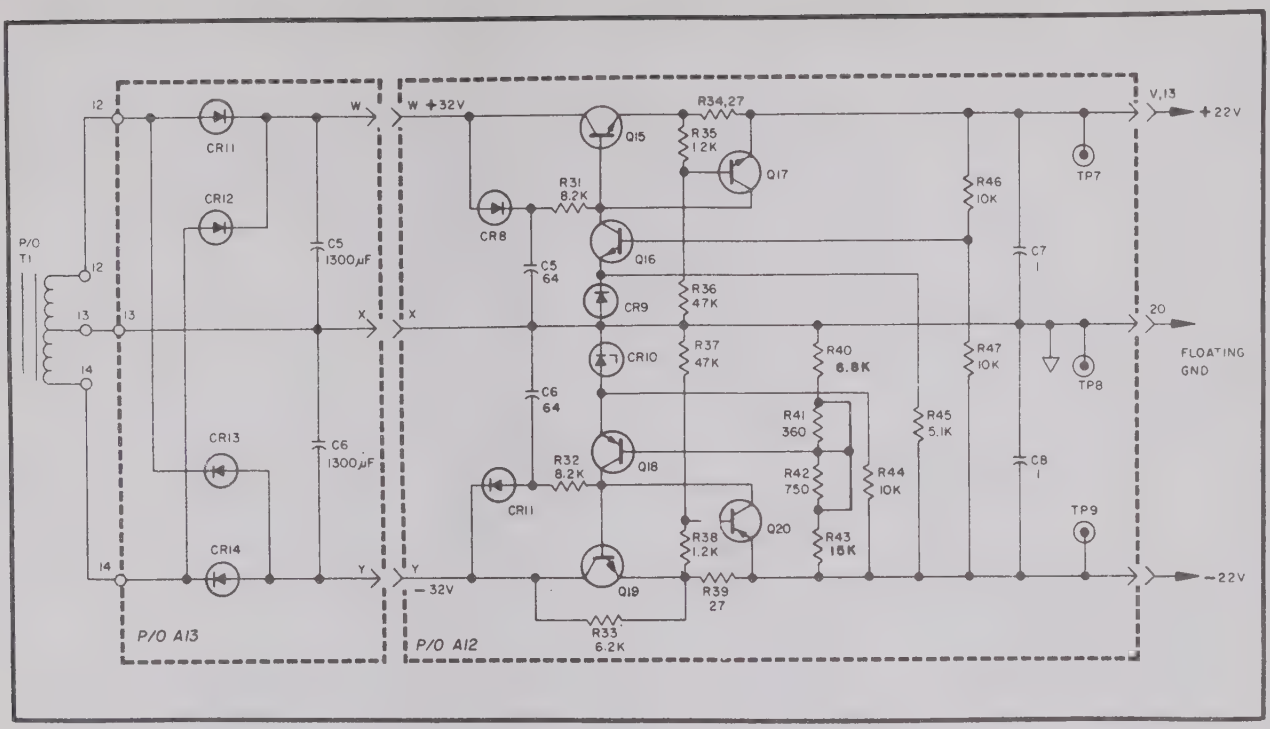


Figure 4-22. +22V Floating Power Supply

4-71. The jumpers across A12R41 and A12R42 can be removed to adjust the output to -22 V. The +22 V supply is referenced to the -22 V supply. R46 and R47 are sensing resistors for the +22 V supply.

4-72. +30 V, +12 V, ±25V POWER SUPPLIES

4-73. Figure 4-23 is a schematic diagram of the +30 V, +12 V, and ±25 V supplies. The +30 V supply is capable of delivering 30 mA. Its main function is to provide relay driving power. Resistor A12R7 and capacitor A12C4 comprise a simple filter network to reduce ripple in the +30 V output. The +12 V, and ±25 V supplies are used to provide circuit levels for V_{CC}, etc. The +12 V supply employs series regulator A12Q14 and reference zener diode A12CR4 to accomplish regulation. Diodes A12CR5, A12CR6, A12CR7 provide additional voltage offset to accomplish the +12 V output.

4-74. Regulation of the +25 V supply is dependent upon the -25 V supply.

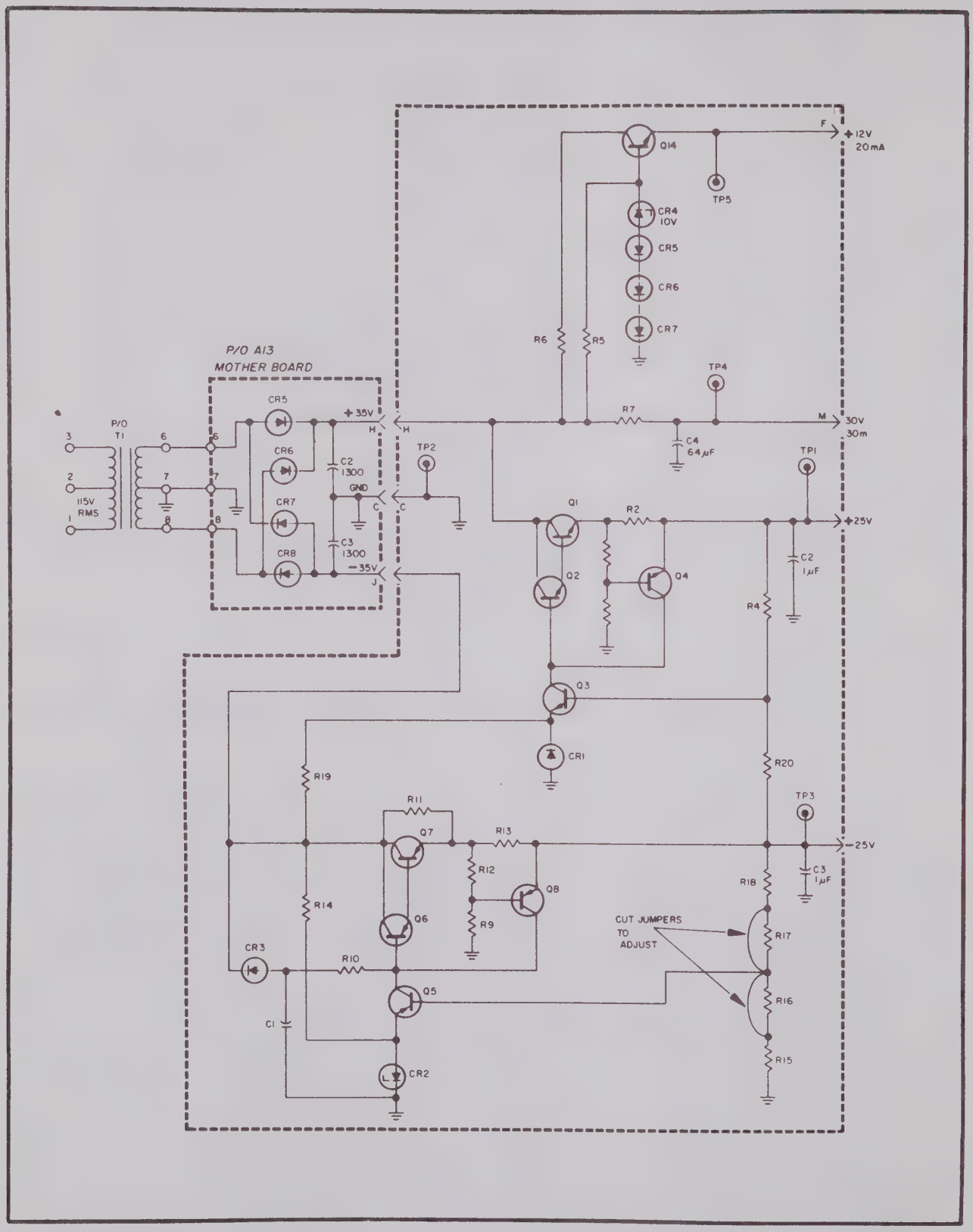


Figure 4-23. +12V, +30V, and ±25V Supplies

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	PURPOSE	CRITICAL SPECIFICATIONS	RECOMMENDED INSTRUMENTS
DC Voltage Standard	Dc voltage alignment and calibration.	Accuracy: ±0.003% Range: 0.1 μV to 1000 V	Fluke Model 332A
Resistance Standard	Resistance alignment and calibration.	Accuracy: ±0.01% 0.1 Ω to 12 MΩ	ESI DB 877
AC Voltage Source	Provide ac test voltage at low distortion.	Stability: ±0.02% Distortion: <0.05% Output: < ADJ to 1000 V 50 Hz to 100 kHz	Optimation, Inc. Model AC-104A and HP 331A (Distortion Analyzer)
Ratio Transformer	Provide low-level ac voltage for linearity test.	Accuracy: 0.01% to 20 kHz	Gertch Model RT13 or Optimation, Inc. Model AC-104A
AC Thermal Transfer	Compare rms value of sinewave voltages from ac source with dc output from dc voltage standard.	Voltage Range: 0.25 V to 1000 V Frequency Range: 50 Hz to 100 kHz AC- DC Difference: ±0.01%	Fluke Model 540B
DC Current Standard	Provide dc current for alignment and calibration.	Current Range: 0.1 μA to 1 A Accuracy: +0.02%	Fluke Model 382A
DC Current Meter	Measure DVM Offset Current.	Current Range: 10 pA to 1 mA Accuracy: 2%	HP Model 425A
Voltmeter	Power Supply Checks.	Range: 1000 V Accuracy: 0.2% Input Resistance: 10 MΩ	Fairchild Model 7100A
Oscilloscope	Ripple measurements.	Passband: dc to 300 kc Sensitivity: 1 mV/cm	Fairchild 767 H

SECTION V

MAINTENANCE

5-1. INTRODUCTION

5-2. This section contains information for calibration, maintenance, and troubleshooting of the Model 7000. Also included is a list of test equipment required for procedures outlined in this section.

5-3. TEST EQUIPMENT REQUIRED

5-4. Table 5-1 lists test equipment required for performance check, troubleshooting, and adjustment. If recommended equipment is not available, equipment with equivalent specifications may be substituted.

5-5. In procedures that involve accurate dc voltage or resistance measurements, care must be taken to ensure consistent results. Working standards should be referred to primary standards on a regular basis. Particular care should be taken with resistance standards that are subject to long-term drift due to aging.

5-6. PERFORMANCE CHECK

5-7. The performance check outlined in the following paragraphs is used to verify specifications of the Model 7000. It can be used upon receipt of a new instrument, for routine preventive maintenance, and following repair of the instrument. The instrument under test may not have all of the measurement mode options included. In this case, it is only necessary to check those modes pertinent to the unit under test.

NOTE

If the instrument fails to meet the performance check at any time, proceed to the appropriate calibration and alignment procedure to correct the malfunction.

5-8. DCV MEASUREMENT ACCURACY CHECK

5-9. To check the accuracy of the Model 7000 for dc voltage measurements, proceed as follows:

a. Make the following initial settings on the Model 7000.

FUNCTION . . . . . VDC.
RANGE . . . . . 1.
PWR . . . . . on (up position).

b. Set the output of the voltage standard to zero.

c. Connect the HI and LO INPUT terminals on the Model 7000 to the (+) and (-) output terminals respectively on the voltage standard.

d. Check accuracy at each setting of voltage standard listed in table 5-2. In each case the readout should be within the tolerance shown.

e. Reduce the voltage standard output to zero and disconnect the test instrument from the Model 7000.

Table 5-2. DC Voltage Measurement Accuracy at 25°C

STANDARD VOLTAGE	RANGE (VDC)	MODEL 7000 READOUT LIMITS	
		MAXIMUM	MINIMUM
0.0000	1	+0.0001	-0.0001
0.3000	1	+0.3001	+0.2999
0.8000	1	+0.8002	+0.7998
1.1000	1	+1.1002	+1.0998
00.000	10	+00.001	-00.001
03.000	10	+03.002	+02.998
08.000	10	+08.002	+07.998
11.000	10	11.002	+10.998
000.00	100	+000.01	-000.01
030.00	100	+030.01	+029.99
080.00	100	080.02	+079.98
110.00	100	110.02	+109.98
0000.0	1000	0000.1	-0000.1
0300.0	1000	0300.1	+0299.9
0800.0	1000	0800.3	+0799.7
1000.0	1000	1000.2	+0999.8

5-10. VAC MEASUREMENT ACCURACY CHECK

5-11. Use the following procedure to verify ac voltage measurement accuracy specifications. Test setup is shown in figure 5-1.

a. Make the following intial settings on the Model 7000.

FUNCTION	VAC.
RANGE	As required.
PWR. ON	on (up position).

b. Disconnect all of the equipment from the ac thermal standard except the dc voltage standard.

c. Set the dc standard voltage to the same amplitude that you will set the rms amplitude of the ac source.

d. Adjust the meter on the ac thermal transfer until a null is obtained.

e. Connect the ac source to the second set of input terminals on the thermal transfer standard and adjust output amplitude. When the rms input from the ac source balances the dc input, the meter on the thermal transfer standard will indicate a null condition.

CAUTION

IN THE FOLLOWING STEPS DO NOT EXCEED MAXIMUM INPUT VOLTAGE RATINGS. DAMAGE TO THE MODEL 7000 MAY RESULT.

FREQUENCY RANGE	MAXIMUM INPUT VOLTAGE
50 Hz to 10 kHz	1000 V
10 kHz to 20 kHz	750 V
20 kHz to 50 kHz	500 V
50 kHz to 100 kHz.	350 V

f. Connect the Model 7000 HI and LO INPUT terminals across the ac source output terminals.

g. Check the accuracy of the Model 7000 at each ac reference voltage listed in table 5-3. In each case the readout should be within the tolerance shown.

NOTE

Each time the reference voltage is changed it will be necessary to repeat steps a through f to ensure the accuracy of the reference.

h. Disconnect all of the equipment.

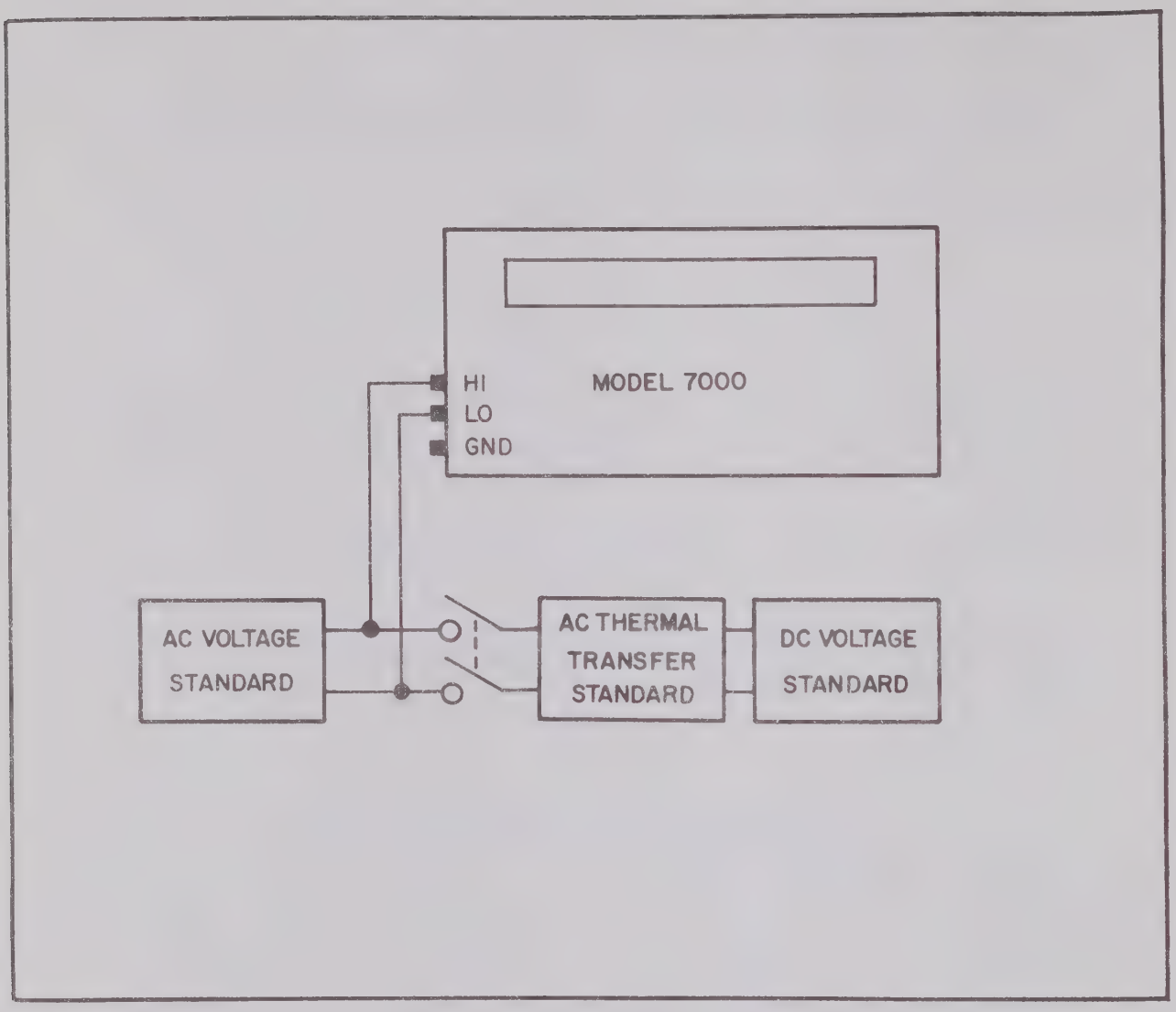


Figure 5-1. AC Voltage Measurement, Accuracy Check

Table 5-3. AC Voltage Measurement Accuracy at 25°C

MODEL 7000	AC VOLTAGE SOURCE		MODEL 7000 READOUT LIMITS	
RANGE (VAC)	FREQUENCY (Hz)	AMPLITUDE (V rms)	MAXIMUM	MINIMUM
1	50 to 10 k	0.0000	0.0002	
		0.5000	0.5007	0.4993
		1.1000	1.1013	1.0987
	10 k to 30 k	0.0000	0.0002	
		0.5000	0.5015	0.4985
		1.1000	1.1033	1.0967
	30 k to 100 k	0.0000	0.0002	
		0.5000	0.5070	0.4930
		1.1000	1.1130	1.0870
10	50 to 10 k	1.100	01.103	01.097
		5.000	05.007	04.993
		11.000	11.013	10.987
	10 k to 30 k	1.100	01.108	01.092
		5.000	05.015	04.987
		11.000	11.031	10.969
	30 k to 100 k	1.100	01.131	01.069
		5.000	05.070	04.930
		11.000	11.130	10.870
	50 k to 10 k	11.00	011.03	010.97
		50.00	050.07	049.93
		110.00	110.13	109.87

Table 5-3 continued on next page.

Table 5-3. AC Voltage Measurement Accuracy at 25°C (Cont)

MODEL 7000 RANGE (VAC)	AC VOLTAGE SOURCE		MODEL 7000 READOUT LIMITS	
	FREQUENCY (Hz)	AMPLITUDE (V rms)	MAXIMUM	MINIMUM
100	10 k to 30 k	11.00	011.08	010.92
		50.00	050.18	049.82
		110.00	110.33	109.67
	30 k to 100 k	11.00	011.31	010.87
		50.00	050.70	049.30
		110.00	110.13	109.87
	50 k to 10 k	110.0	0110.3	0109.7
		500.0	0500.7	0499.3
		1000.0	1001.2	0998.8
1000	10 k to 30 k	110.0	0110.8	0109.2
		500.0	0501.8	0498.2
		750.0	0752.4	0747.6
	30 k to 50 k	110.0	0110.8	0109.2
		500.0	0501.8	0498.2
	30 k to 50 k	110.0	0113.1	0106.9
		500.0	0507.0	0493.0
	50 k to 100 k	110.0	0113.1	0106.9
		350.0	0355.5	0344.5

5-12. RESISTANCE MEASUREMENT ACCURACY CHECK

5-13. Verify kΩ measurement accuracy specifications using the following procedure.

a. Make the following initial settings on the Model 7000.

FUNCTION . . . . . kΩ.
RANGE . . . . . 1.
PWR ON . . . . . on (up position).

b. Set the standard resistance to 1 kΩ.

c. Connect the HI and LO INPUT terminals on the Model 7000 to the output terminals on the resistance standard.

d. Check accuracy at each setting on the resistance standard listed in table 5-4. In each case the readout should be within the tolerance shown.

e. Disconnect the resistance box from the Model 7000.

Table 5-4. Resistance Measurement Accuracy Check at 25°C

MODEL 7000 RANGE (kΩ)	STANDARD RESISTANCE	READOUT LIMITS	
		MAXIMUM	MINIMUM
1	0.0000	0.0002	
	0.2500	0.2503	0.2497
	0.6000	0.6005	0.5995
	1.1000	1.1008	1.0992
10	1.100	01.103	01.097
	2.500	02.503	02.497
	6.000	06.005	05.995
	11.000	11.008	10.992
100	11.00	011.03	010.97
	25.00	025.03	024.97
	60.00	060.05	059.95
	110.00	110.08	109.92
1000	110.0	0110.4	0109.6
	250.0	0250.6	0249.4
	600.0	0600.9	0599.1
	1100.0	1101.4	1098.6
10 MΩ	1100	01107	01093
	2500	02510	02490
	6000	06017	05983
	10000	10025	09975

5-14. MADC MEASUREMENT ACCURACY CHECK (at 25°C)

5-15. Use the following procedure to verify dc current measurement accuracy:

a. Make the following initial settings on the Model 7000.

FUNCTION . . . . . MA DC.
RANGE . . . . . 1.
PWR. ON . . . . . on (up position).

CAUTION

DO NOT APPLY CURRENTS IN EXCESS OF 2 AMPS TO THE MODEL 7000. DAMAGE TO THE INSTRUMENT MAY RESULT.

b. Set the current output from the dc current standard to zero and connect the current standard output terminals to the HI and LO INPUT terminals on the Model 7000.

c. Check accuracy at each setting on the dc current standard listed in table 5-5. In each case the readout should be within the tolerance shown.

d. Disconnect the current source from the Model 7000.

Table 5-5. DC Current Measurement Accuracy at 25°C

MODEL 7000 RANGE (MA DC)	STANDARD DC CURRENT (milliamps)	MODEL 7000 READOUT LIMITS	
		MAXIMUM	MINIMUM
1	0.0000	+0.0002	-0.0002
	0.2500	0.2506	0.2494
	0.6000	0.6010	0.5990
	1.1000	1.1017	1.0983
10	1.100	01.104	01.096
	2.500	02.506	02.494
	6.000	06.010	05.990
	11.000	11.017	10.983
100	11.00	011.04	010.96
	25.00	025.06	024.94
	60.00	060.10	059.90
	110.00	110.17	109.83
1000	110.0	0110.4	0109.6
	250.0	0250.6	0249.4
	600.0	0601.0	0599.0
	1000.0	1001.5	0998.5

5-16. AUTOMATIC RANGING CHECK

5-17. Use the following procedure to check automatic ranging operation.

a. Make the following initial settings on the Model 7000.

FUNCTION	VDC.
RANGE	AUTO.
PWR. ON	on (up position).

b. Set the output of the dc voltage standard to zero.

c. Connect the HI and LO INPUT terminals on the Model 7000 to the output terminals on the voltage standard.

d. Set the dc voltage standard output to 1.19999. The Model 7000 should read on the 1 V scale.

e. Set the dc voltage standard output to 1.2000 V. The Model 7000 readout should uprange to the 10 V range.

f. Set the voltage standard output to 00.9810 V. Instrument should remain in the 10 V range.

g. Set voltage standard output to 00.9800. Instrument should downrange to 1 V range.

h. Check remaining ranges using table 5-6. Unit should change ranges at voltages listed.

Table 5-6. Auto-Ranging

RANGE	RANGE CHANGE		VOLTAGE	
	UP MIN	UP MAX	DOWN MIN	DOWN MAX
1	1.2000	1.2009	———	
10	12.000	12.009	00.980	00.971
100	120.00	120.09	009.80	009.71
1000	———		0098.0	0097.1

5-18. OVERLOAD INDICATOR CHECK

5-19. Check the operation of the overload indicator using the following procedure:

a. Make the following initial settings on the Model 7000.

FUNCTION	VDC.
RANGE	1.
PWR. ON	on (up position).

b. Set the output of the dc voltage standard to zero.

c. Connect the HI and LO INPUT terminals on the Model 7000 to the output terminals on the dc voltage standard.

d. Increase the dc voltage standard to 1.2000. OVERLOAD indicator should NOT light.

e. Momentarily increase the dc voltage to 1.2005. Indicator should start blinking at this point. Decrease dc input voltage.

f. Disconnect the dc voltage standard from the Model 7000.

5-20. NORMAL MODE REJECTION CHECK

5-21. To check the normal mode rejection capability of the Model 7000 use the following procedure:

a. Connect the Model 7000 into the test setup shown in figure 5-2 and make the following initial settings on the Model 7000.

FUNCTION	VDC.
RANGE	1.
PWR. ON	on (up position).

b. Set the ac source output to zero.

c. Adjust the dc source to give a stable 0.5000 VDC readout on the Model 7000.

d. Increase ac voltage (60 Hz) until one digit change (or jitter) takes place. Note ac voltage reading.

e. Check the normal mode rejection at each of the frequencies listed in table 5-7.

Table 5-7. Normal Mode Rejection

FREQUENCY	MINIMUM AC VOLTAGE
60 Hz	32 mV peak or 23 mV rms
120 Hz	100 mV peak or 70.7 mV rms
400 Hz	210 mV peak or 148 mV rms

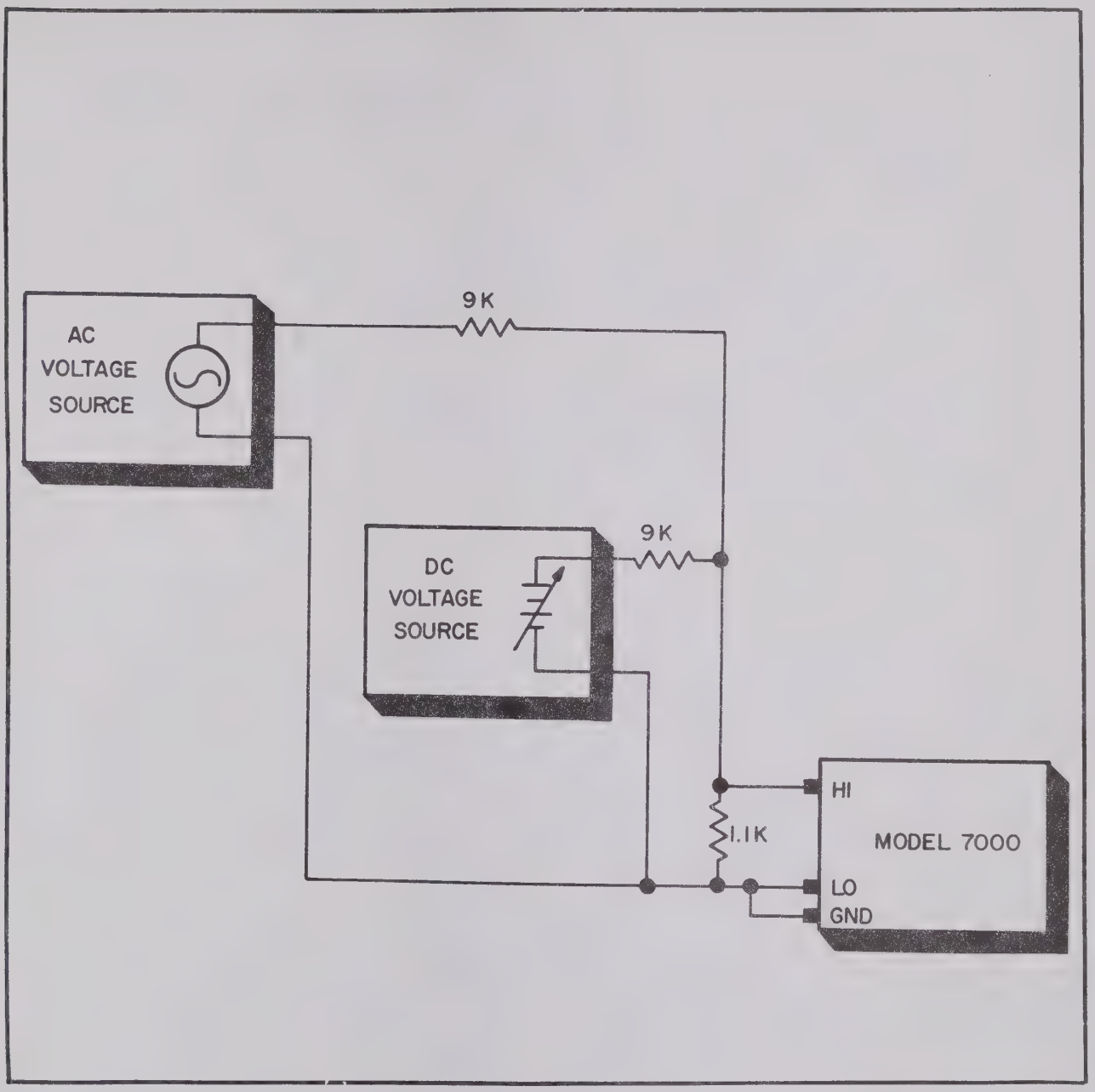


Figure 5-2. Normal Mode Rejection Test Setup

5-22. PERIODIC MAINTENANCE

5-23. The Model 7000 requires little periodic maintenance. The procedure in the following paragraphs may be used when maintenance is performed on a regular basis.

5-24. INSPECTION

5-25. Remove top and bottom covers from instrument. Inspect the chassis and mounted components for damage, signs of overheating, etc. Remove circuit boards and inspect for damage or signs of failure. Using low pressure, dry, compressed air, blow out any dust accumulation.

5-26. Rotate front-panel controls through full range, noting any binding or rough action.

5-27. Following inspection, replace all circuit boards and covers. Make performance check detailed in paragraphs 5-6 through 5-21.

5-28. ALIGNMENT AND CALIBRATION PROCEDURES

5-29. Alignment procedures outlined in the following paragraphs can be used for calibrating a field-installed option plug-in board, for routine preventative maintenance, and following repair. The multimeter under test may not have all of the options included. In this case, it is only necessary to align and calibrate those parts that are pertinent to the unit under test.

5-30. DC POWER SUPPLY CHECK

5-31. On the rear panel, slide the 115/230 Vac switch to the 115 V position. Turn on the power switch and proceed in the following steps. Line voltage must be 115 V 50 to 400 Hz. (See table 5-8.)

Table 5-8. DC Power Supply Checkout

STEP NO.	BETWEEN TEST POINTS	VOLTAGE LIMITS	ADJUSTMENTS AND COMMENTS	MAXIMUM RIPPLE
1	TP2 and TP 4	+28 V to 40 V	Non-regulated supply, no adjustment.	$\leq$ 300 mV rms
2	TP5 and TP2	+8 V to 12 V	Semiregulated supply, no adjustment.	$\leq$ 100 mV rms
3	TP2 and TP 3	-24.5 V to 25.5 V	Remove jumper across A12-R17 to increase voltage. Remove jumper across A12-R16 to decrease voltage.	$\leq$ 5 mV rms
4	TP2 and TP 1	+24.0 V to 26.0 V	No adjustment necessary.	$\leq$ 5 mV rms
5	TP2 and TP 6	+3.6 V to 4.0 V	Remove jumper across A12-R28 to increase voltage. Remove jumper across A12-R29 to decrease voltage.	$\leq$ 50 mV rms
6	TP8 and TP9	-22.5 V to 25.5 V	Remove jumper across A12-R42 to increase voltage. Remove jumper across A12-R41 to decrease voltage.	$\leq$ 5 mV rms
7	TP7 and TP8	+22.0 V to 26.0 V	No adjustments necessary.	$\leq$ 5 mV rms
8	A12-1 and A12-3	+170 V to 230 V	No adjustments necessary.	$\leq$ 3 V rms

5-32. ALIGNMENT PROCEDURE

5-33. Each mode of operation can be checked and adjusted using the following procedure. Refer to figure 5-3 in the back of this section when necessary for determining adjustment points. (See table 5-9).

Table 5-9. Meter Adjustments

STEP NO.	FUNCTION	RANGE	INPUT	ADJUSTMENT
1	VDC	1	--	With ammeter between high and low terminal, adjust A7-C5 for $\leq$ 50 pA offset current.
2	VDC	1	±3.05 mV	Adjust A7-R32 for symmetrical readout around zero (readout should blink between 3.0 and 3.1 mV for both polarities).
3	VDC	1	shorted	Adjust A6-R46 for uncertain plus-minus indication, then favor positive indication by 1/2 turn (clockwise).
4	VDC	1	-1.0000 V	Adjust A6-R12 for full scale reading of -10000 V.
5	VDC	1	+1.0000 V	Readout shall be +1.0000 V ±1 digit.
6	VDC	1	+0.0010 V	Adjust A6-R44 for readout of +0.0010 V. Repeat steps 2 through 5 for final adjustment.
7	VDC	10	-10.000 V	Adjust A7-R58 for readout of -10.000 V.
8	VDC	10	+10.000 V	Readout shall be +10.000 V ±1 digit.
9	VDC	100	-100.00 V	Adjust A8-R3 for readout of -100.00 V.
10	VDC	100	+100.00 V	Readout shall be +100.00 V ±1 digit.
11	VDC	1000	±1000.0 V	Readout shall be ±1000.0 V ±2 digit.
12	TEST	10	None	Adjust A8-R9 for readout of 010.00.
13	kΩ	100	100.00 kΩ	Adjust A10-R8 for readout of 100.00 kΩ.
14	kΩ	10	10.000 kΩ	Adjust A8-R5 for readout of 10.000 kΩ.
15	DCMA	1	+1.0000 mA	Adjust A14-R14 for readout of +1.0000 mA.
16	DCMA	10	+10.000 mA	Adjust A14-R11 for readout of +10.000 mA.
17	DCMA	100	+100.00 mA	Adjust A14-R8 for readout of +100.00 mA.
18	DCMA	1000	+1000.0 mA	Adjust A14-R5 for readout of +1000.0 mA.
19	VAC	1	1.0000 V 400 Hz	Adjust A9-R for readout of 1.0000 Vac.
20	VAC	1	1.0000 V 10 kHz	Adjust A9-C for readout of 1.0000 Vac.
21	VAC	1	1.0000 V 80 kHz	Adjust A9-C for readout of 1.0000 Vac.
22	VAC	10	10.000 V 400 Hz	Adjust A9-R for readout of 10.000 Vac.
23	VAC	10	10.000 V 80 kHz	Adjust A9-C for readout of 10.000 Vac.
24	VAC	100	100.00 V 400 Hz	Adjust A9-R for readout of 100.00 Vac.
25	VAC	100	100.00 V 80 kHz	Adjust A9-C for readout of 100.00 Vac.

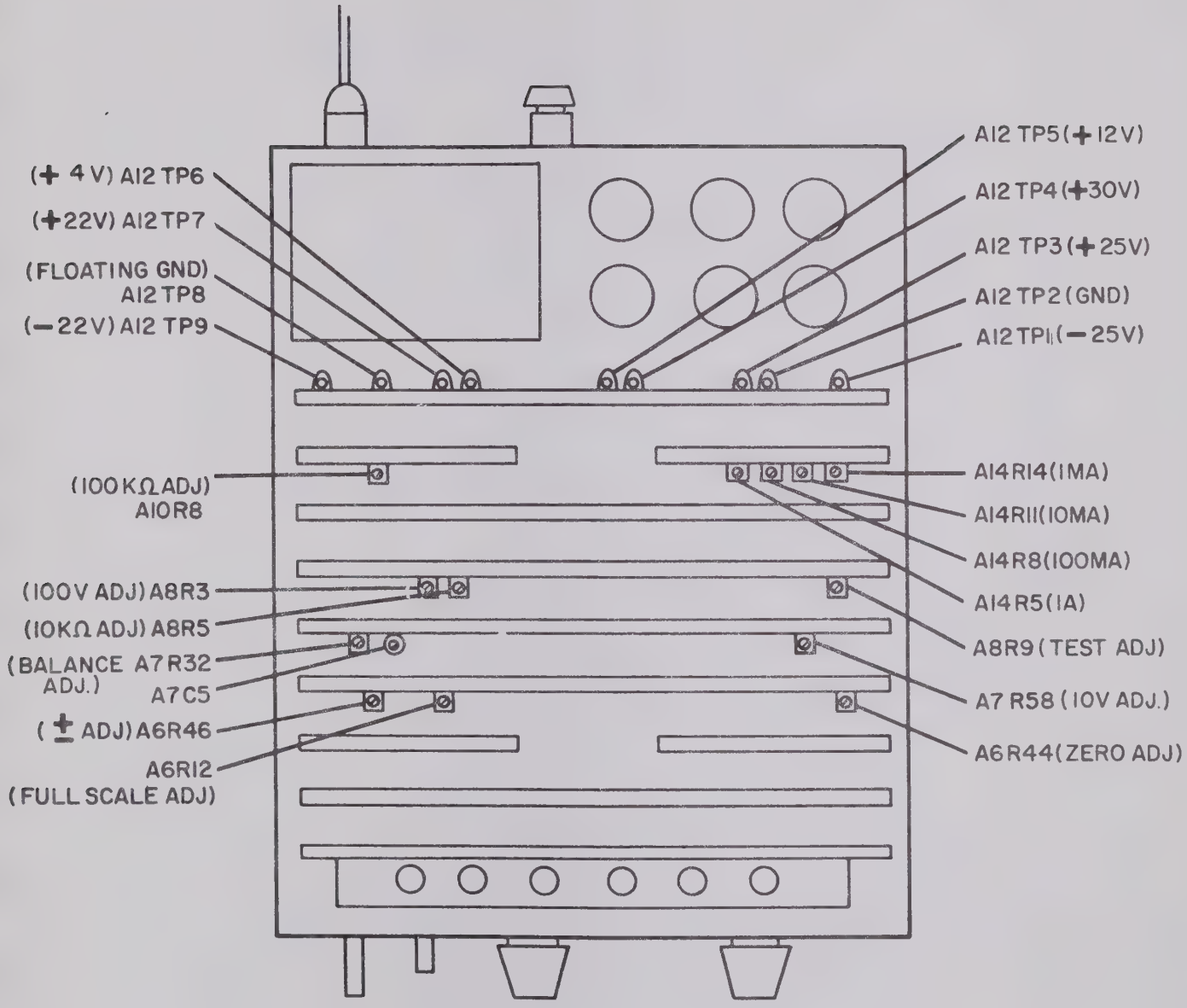


Figure 5-3. Adjustments and Test Points

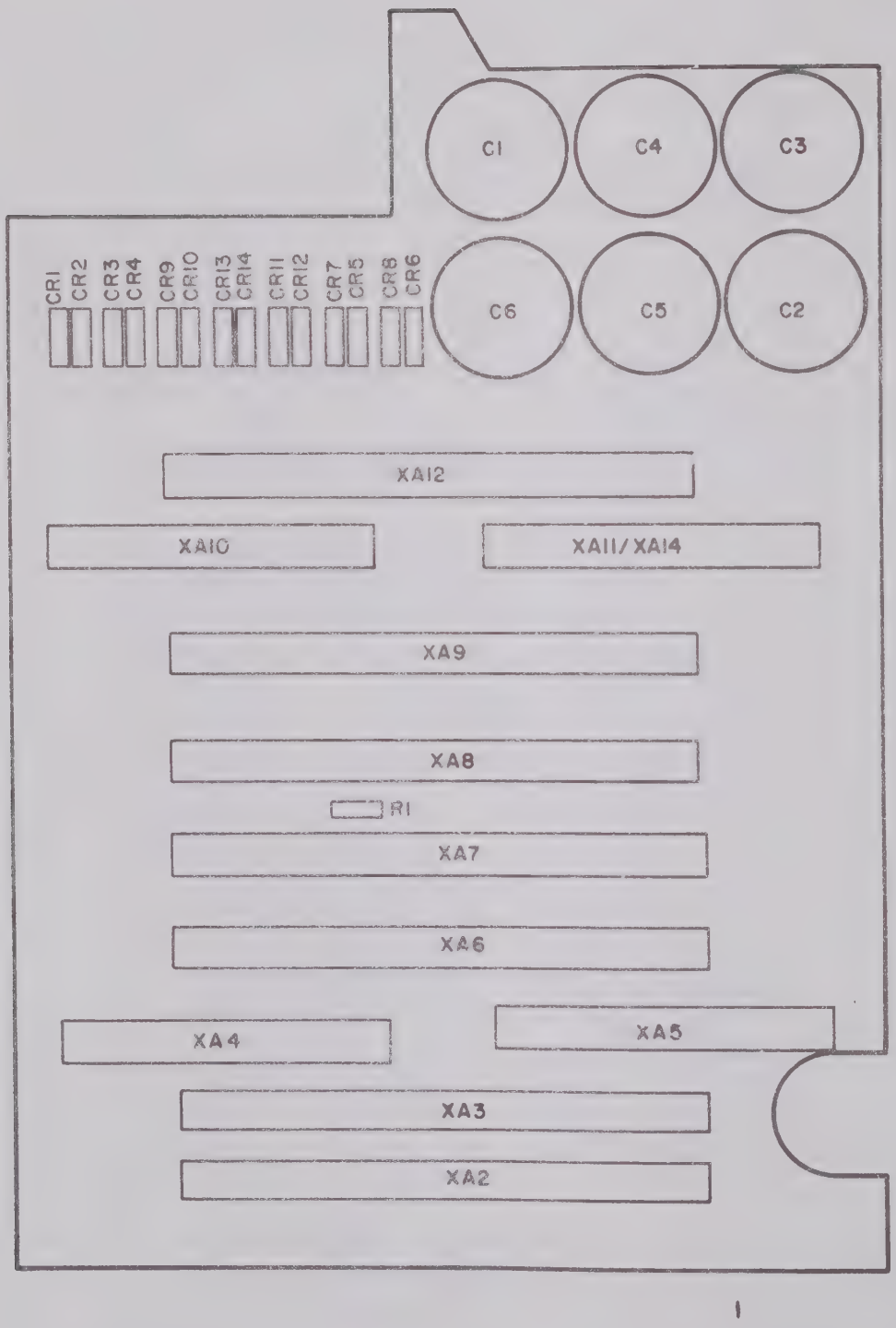


Figure 5-4. Component Location, Mother Board A13

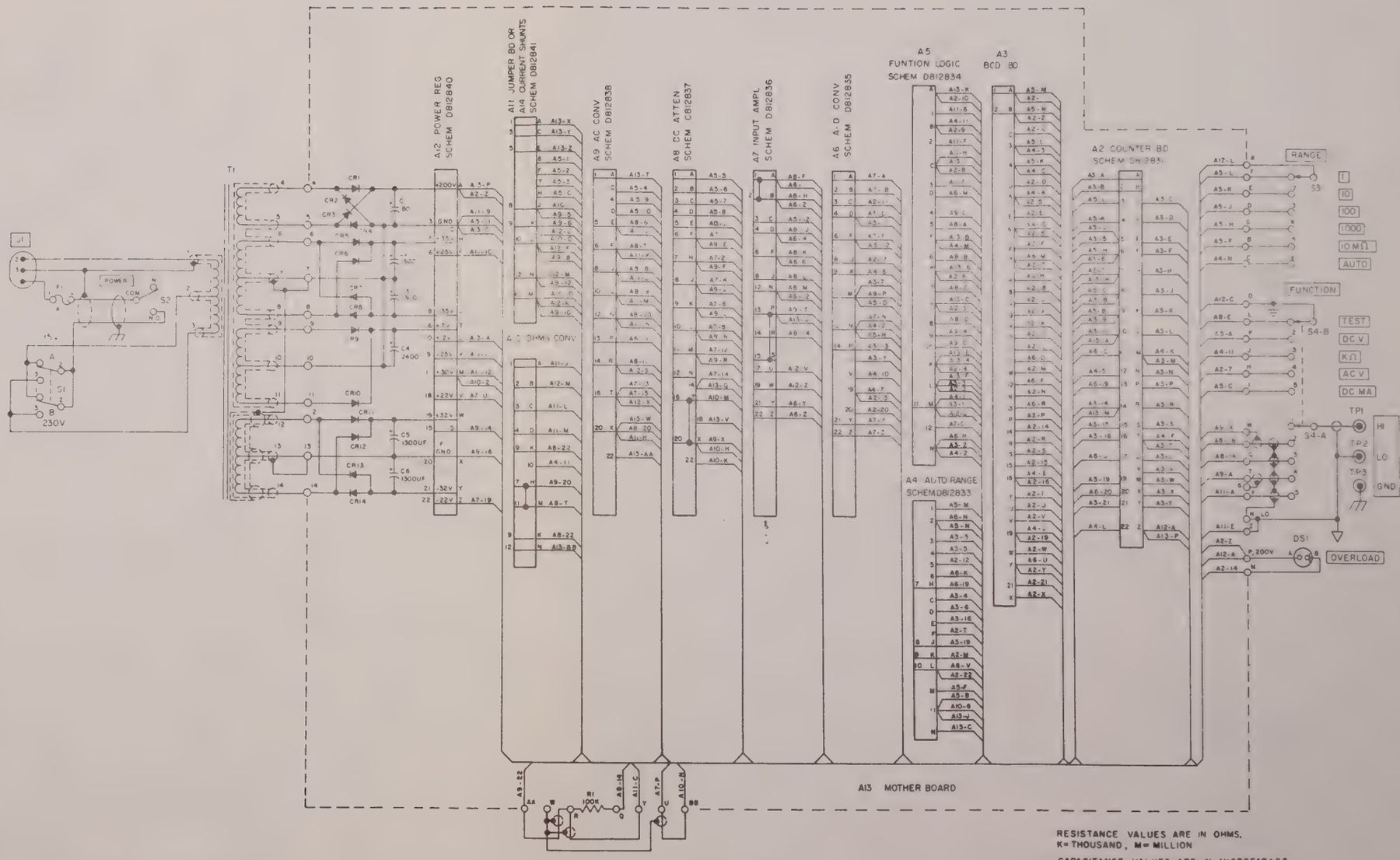


Figure 5-5. Wiring Diagram, Model 7000

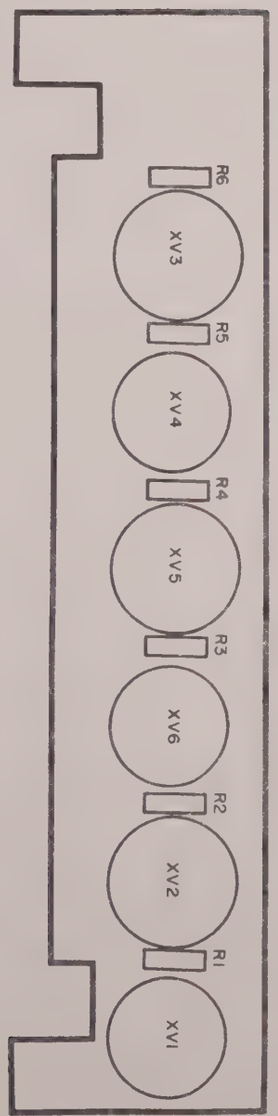


Figure 5-6. Component Location, Readout Assembly A1

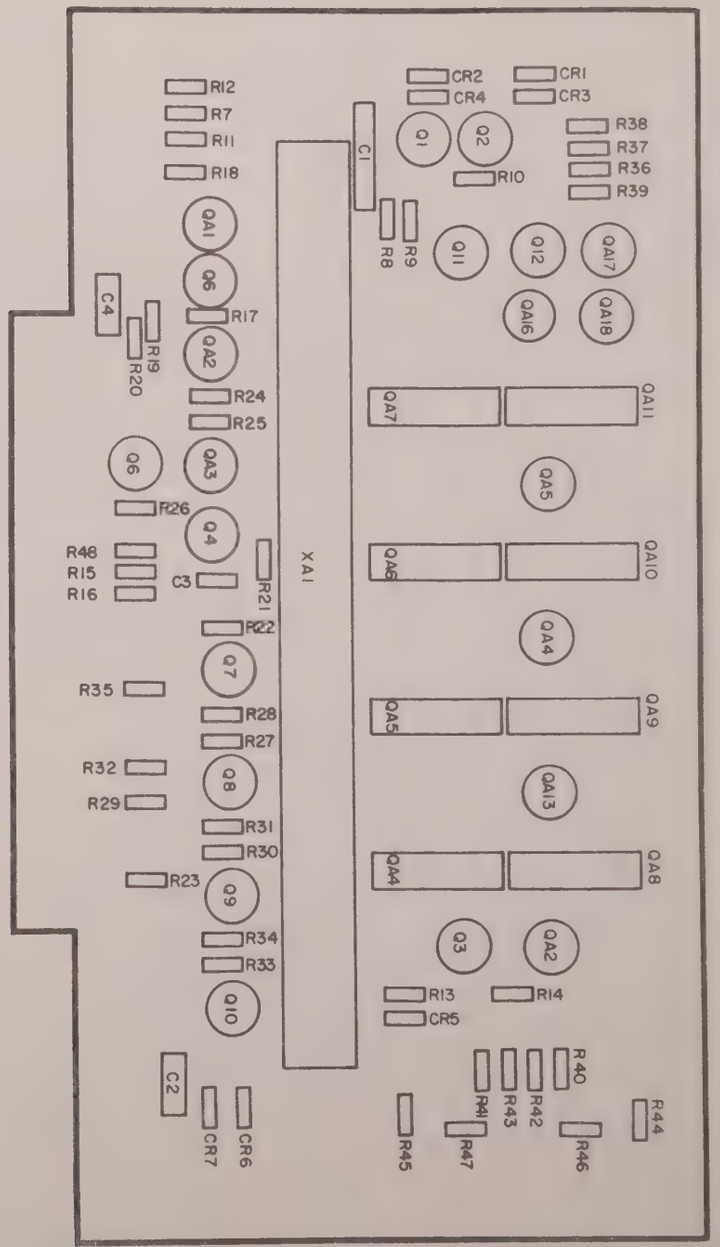


Figure 5-7. Component Location, Counter Assembly A2

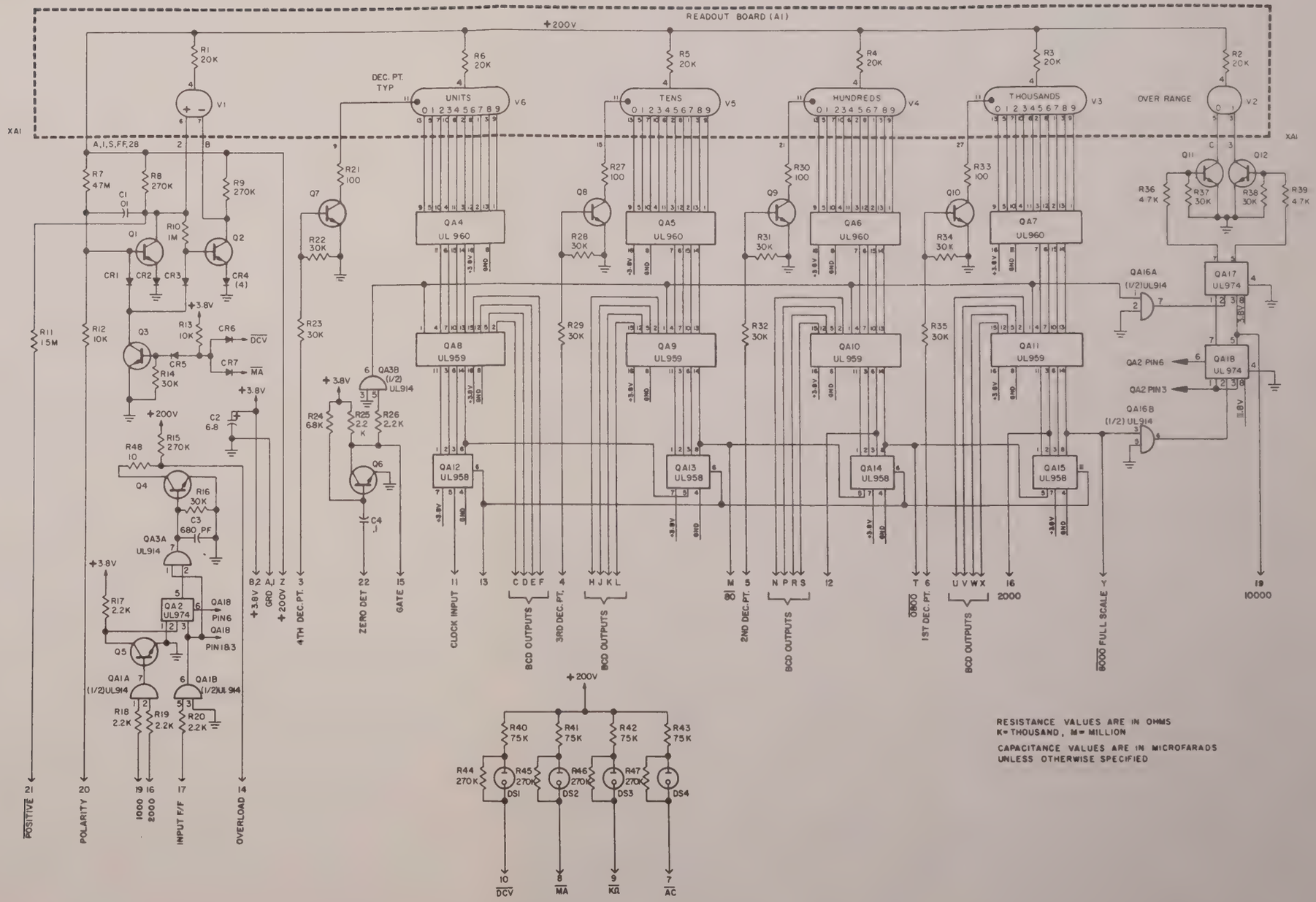


Figure 5-8. Schematic Diagram, Readout Assembly A1 and Counter Assembly A2

Component Location, BCD Assembly A3 is
not available at present.

Figure 5-9. Component Location, BCD Assembly A3

Schematic, BCD Assembly A3 is
not available at present.

Figure 5-10. Schematic Diagram , BCD Assembly A3

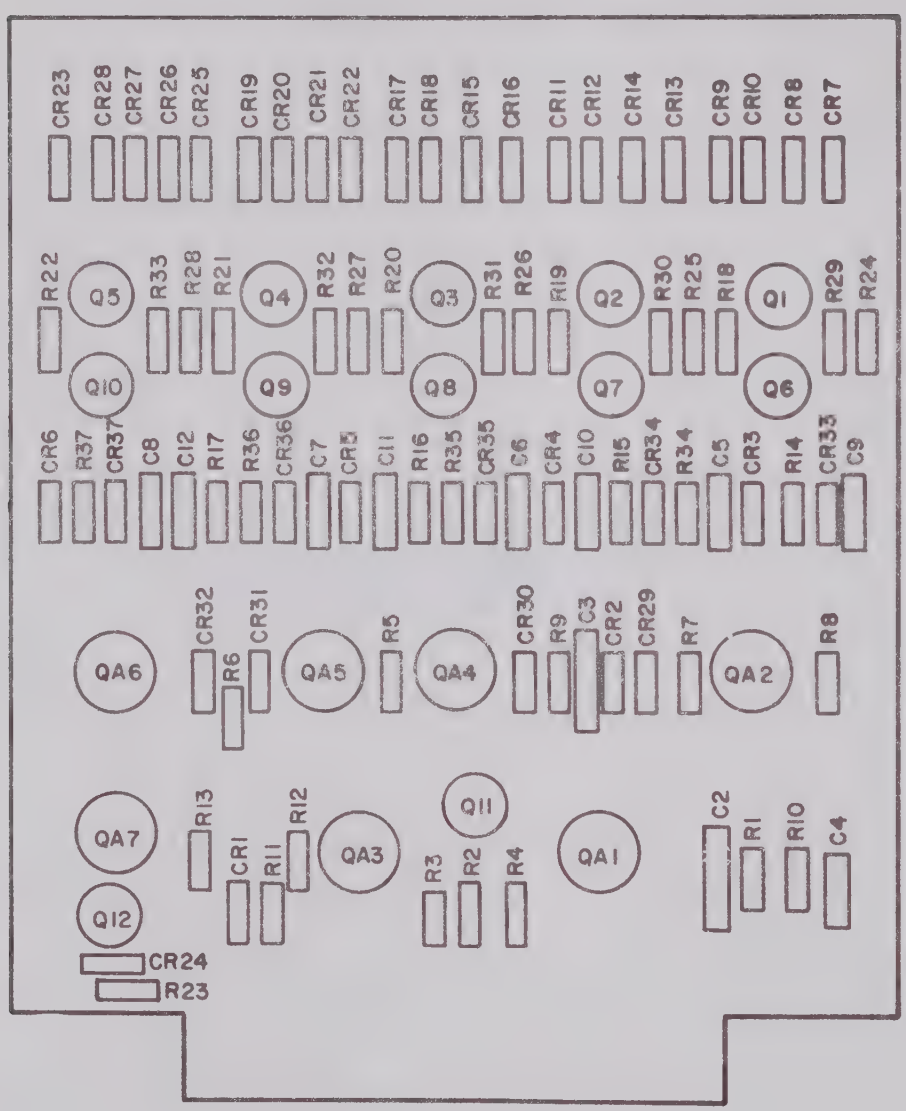
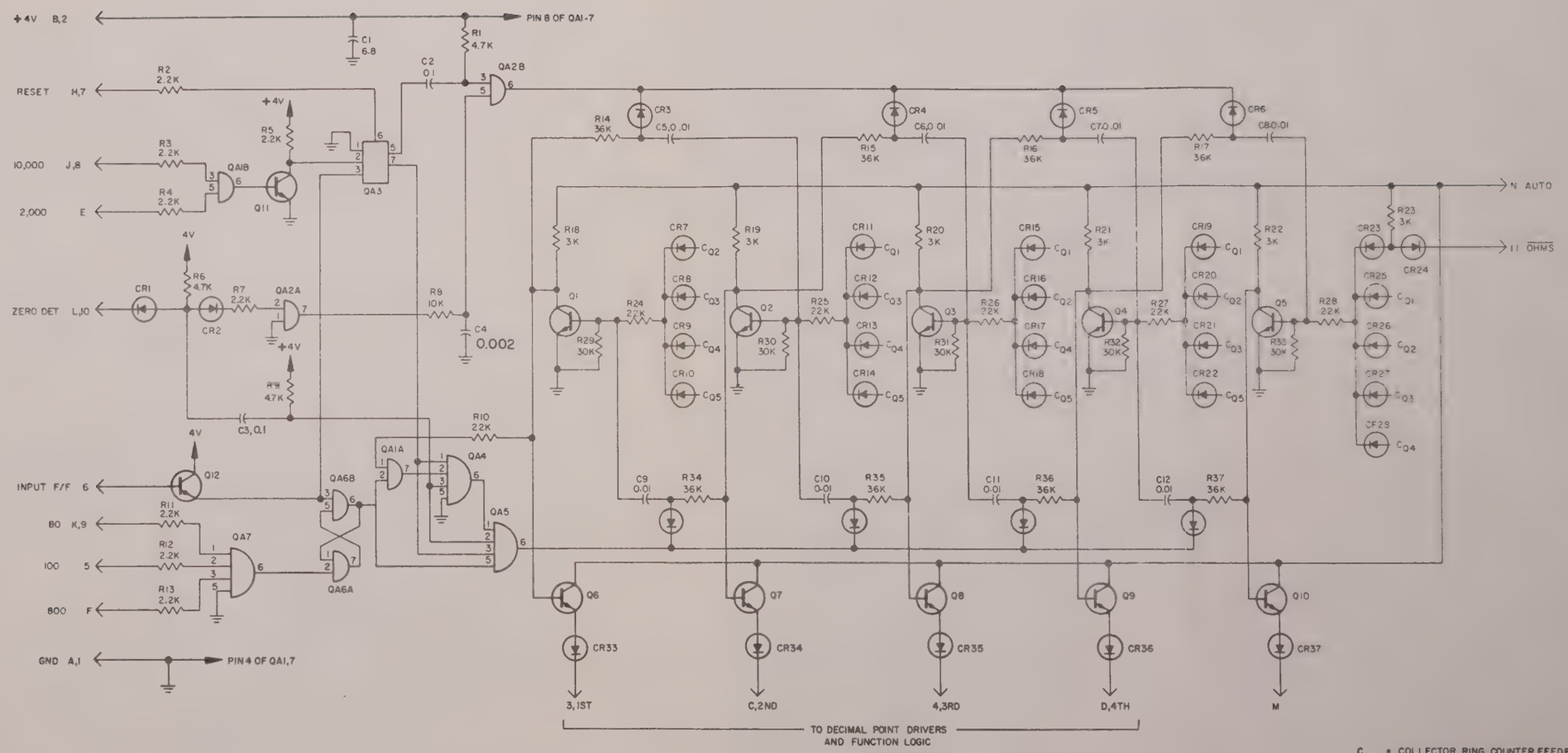


Figure 5-11. Component Location, Autorange Assembly A4



C_{QX} = COLLECTOR RING COUNTER FEEDBACK. ANODE OF DIODE INDICATED IS RETURNED TO COLLECTOR OF TRANSISTOR INDICATED.

RESISTANCE VALUES ARE IN OHMS
K = THOUSAND, M = MILLION

CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED

Figure 5-12. Schematic Diagram, Autorange Assembly A4

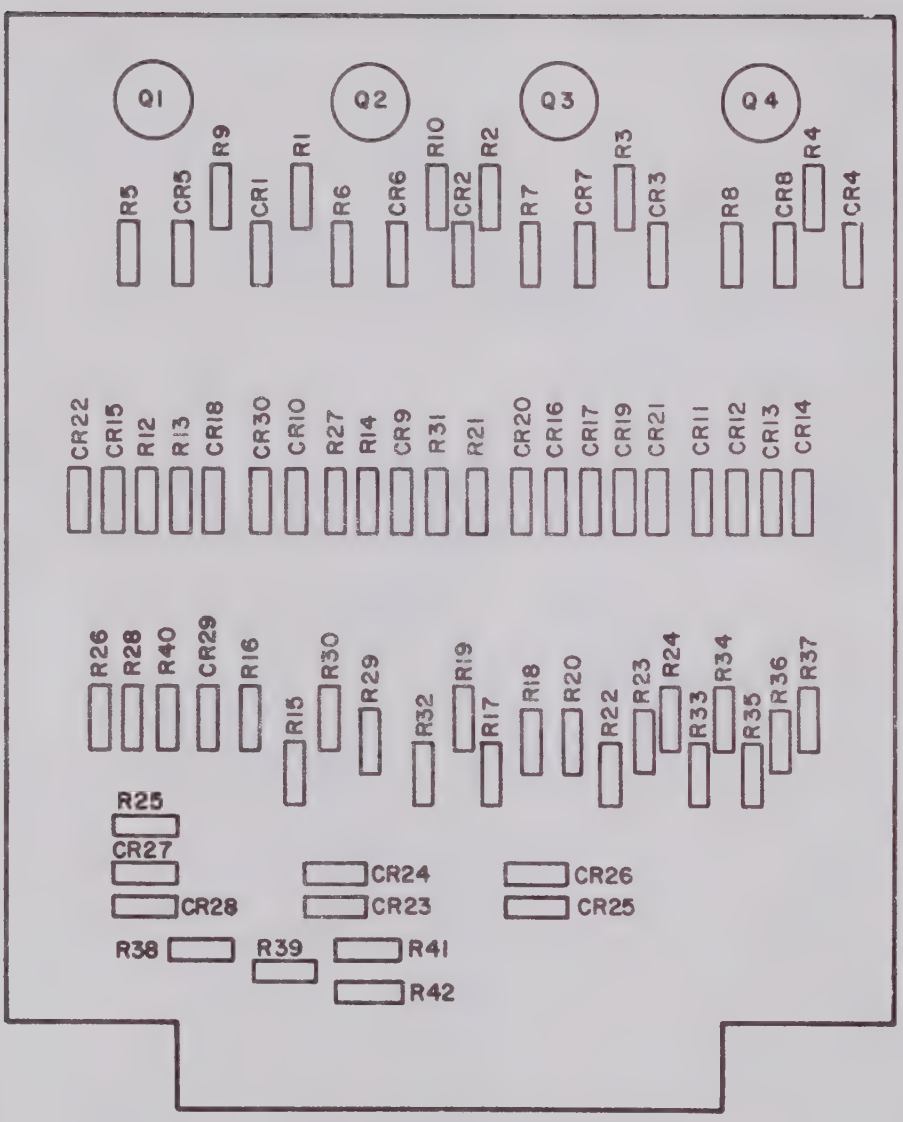


Figure 5-13. Component Location, Function Logic Assembly A5

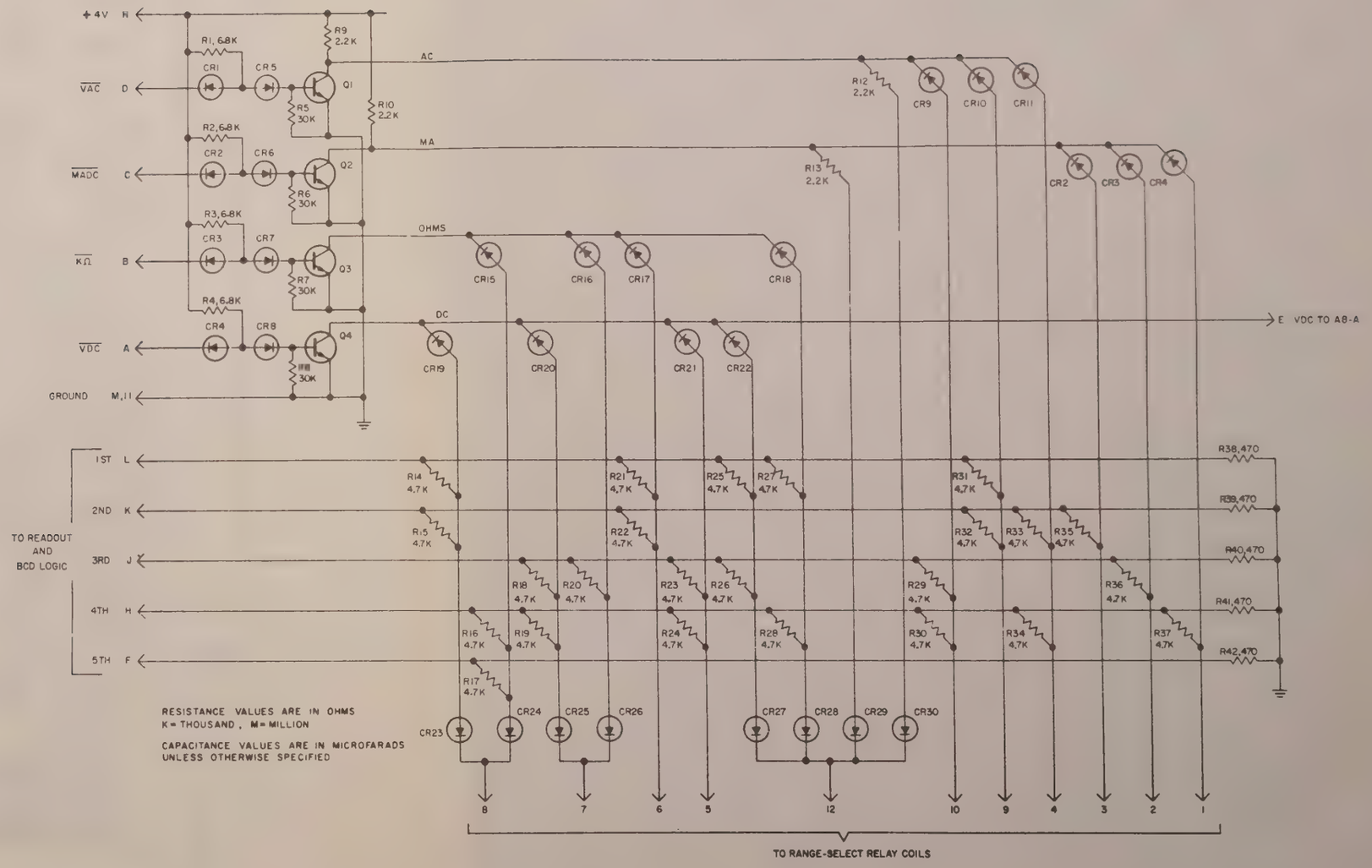


Figure 5-14. Schematic Diagram, Function Logic Assembly A5

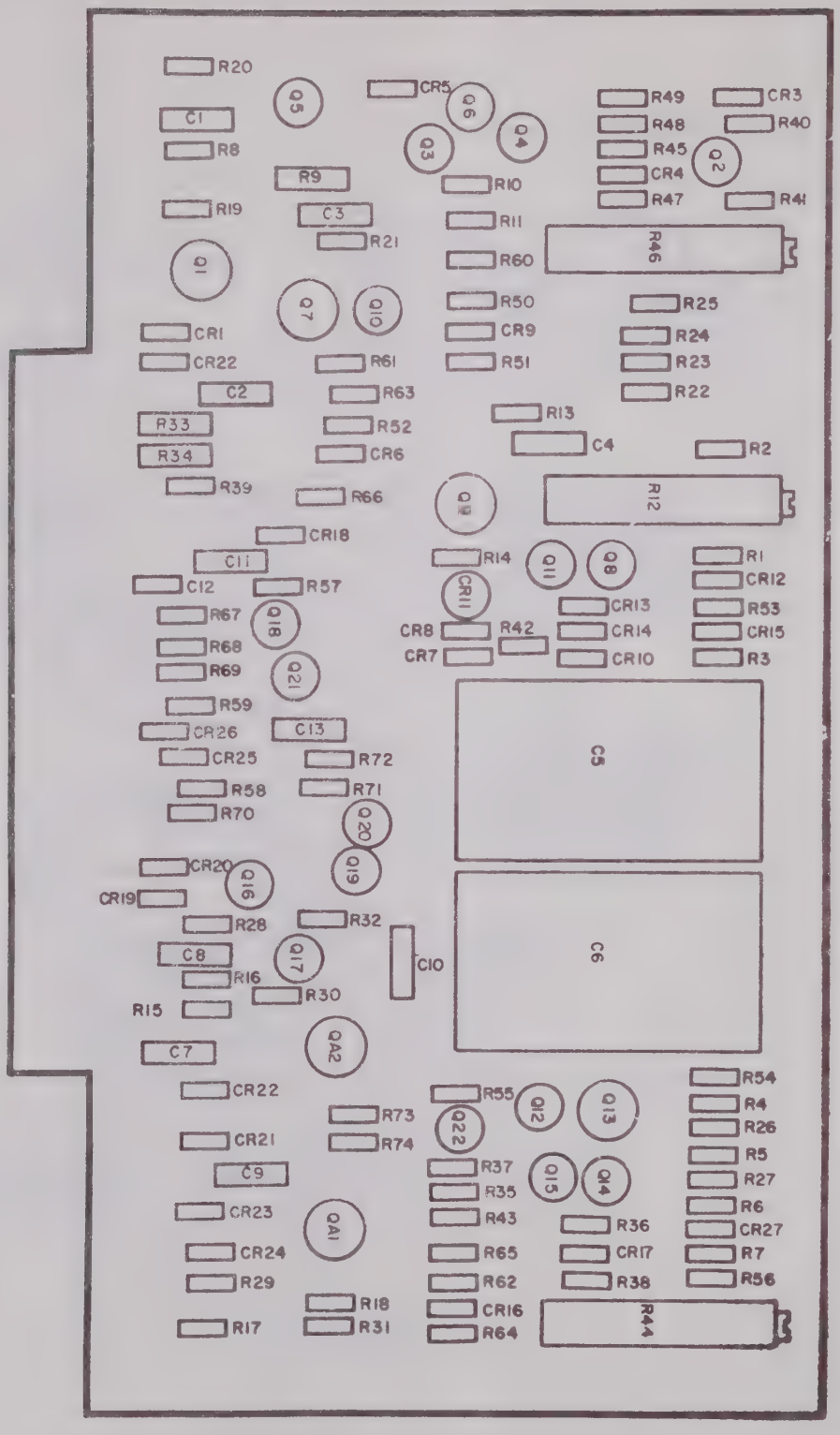


Figure 5-15. Component Location, A to D Converter Assembly A6

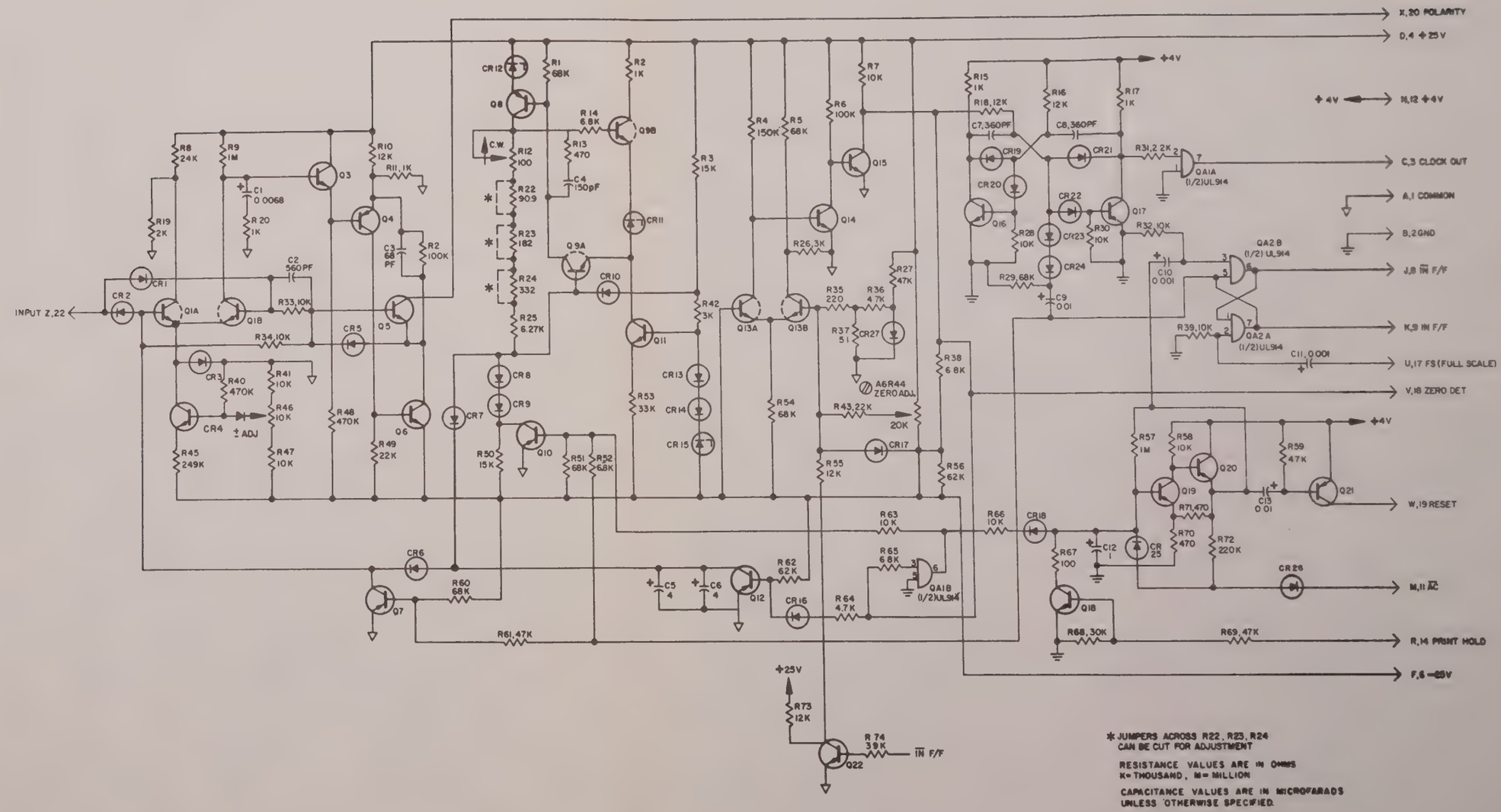


Figure 5-16. Schematic Diagram, A to D Converter Assembly A6

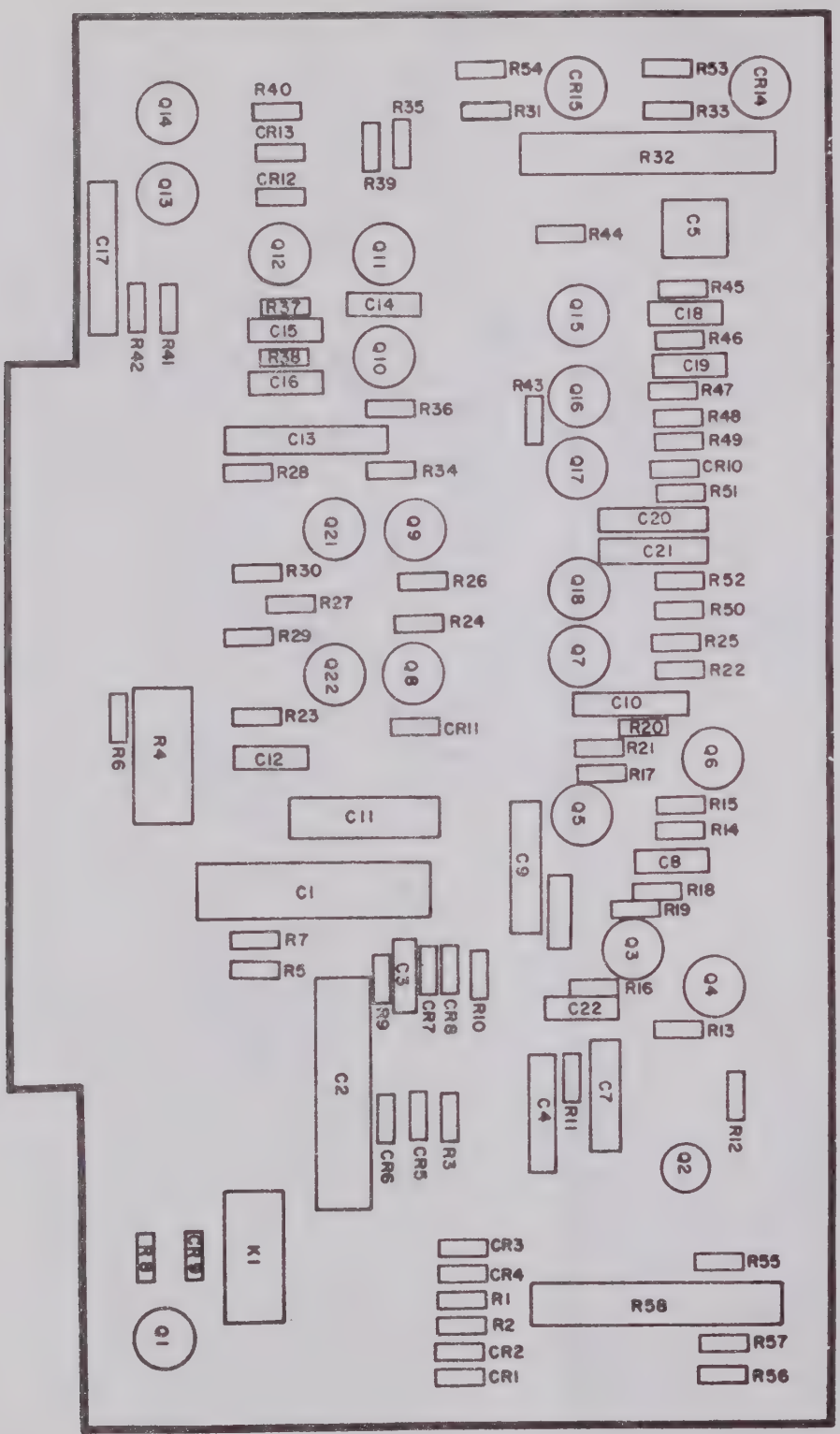


Figure 5-17. Component Location, Input Amplifier Assembly A7

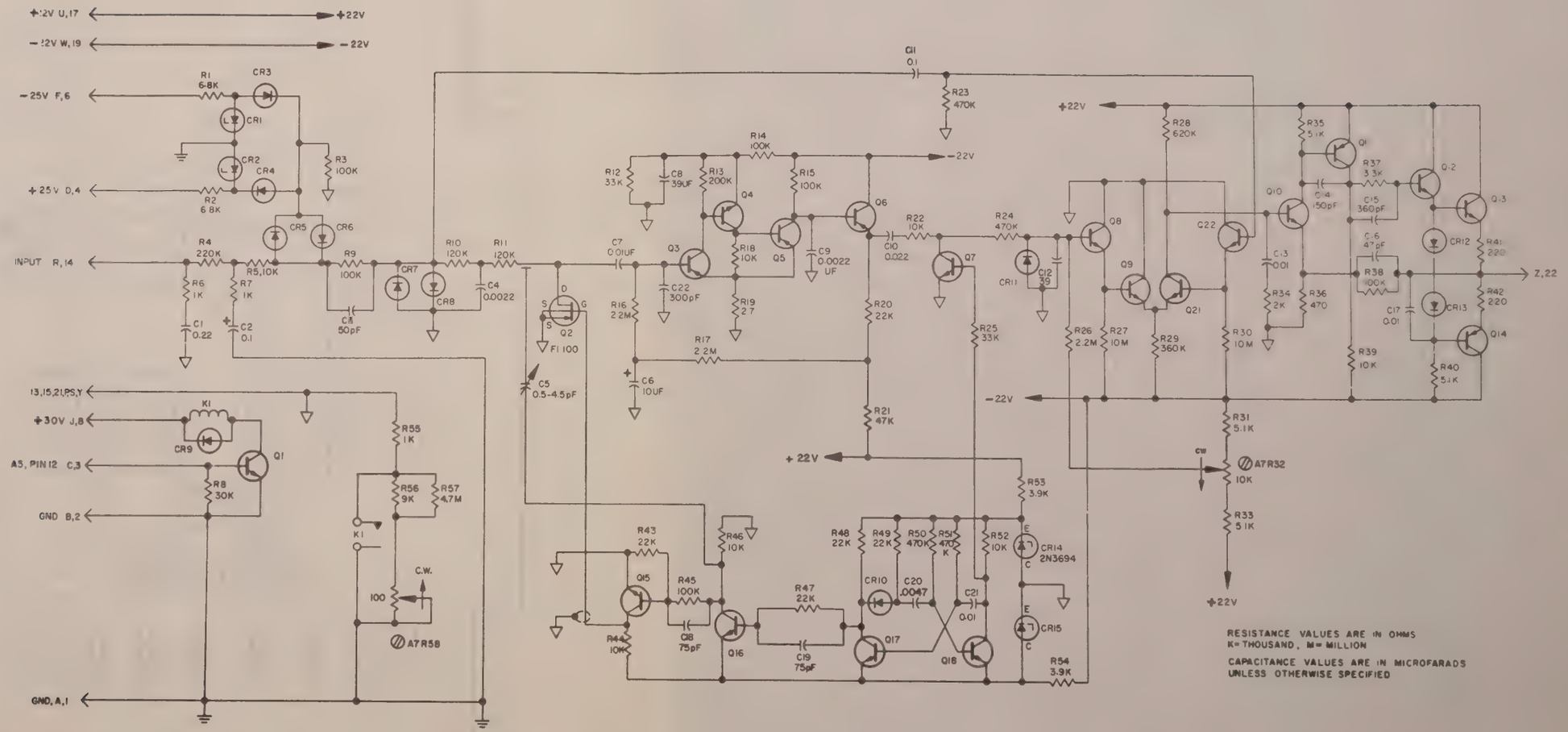


Figure 5-18. Schematic Diagram, Input Amplifier Assembly A7

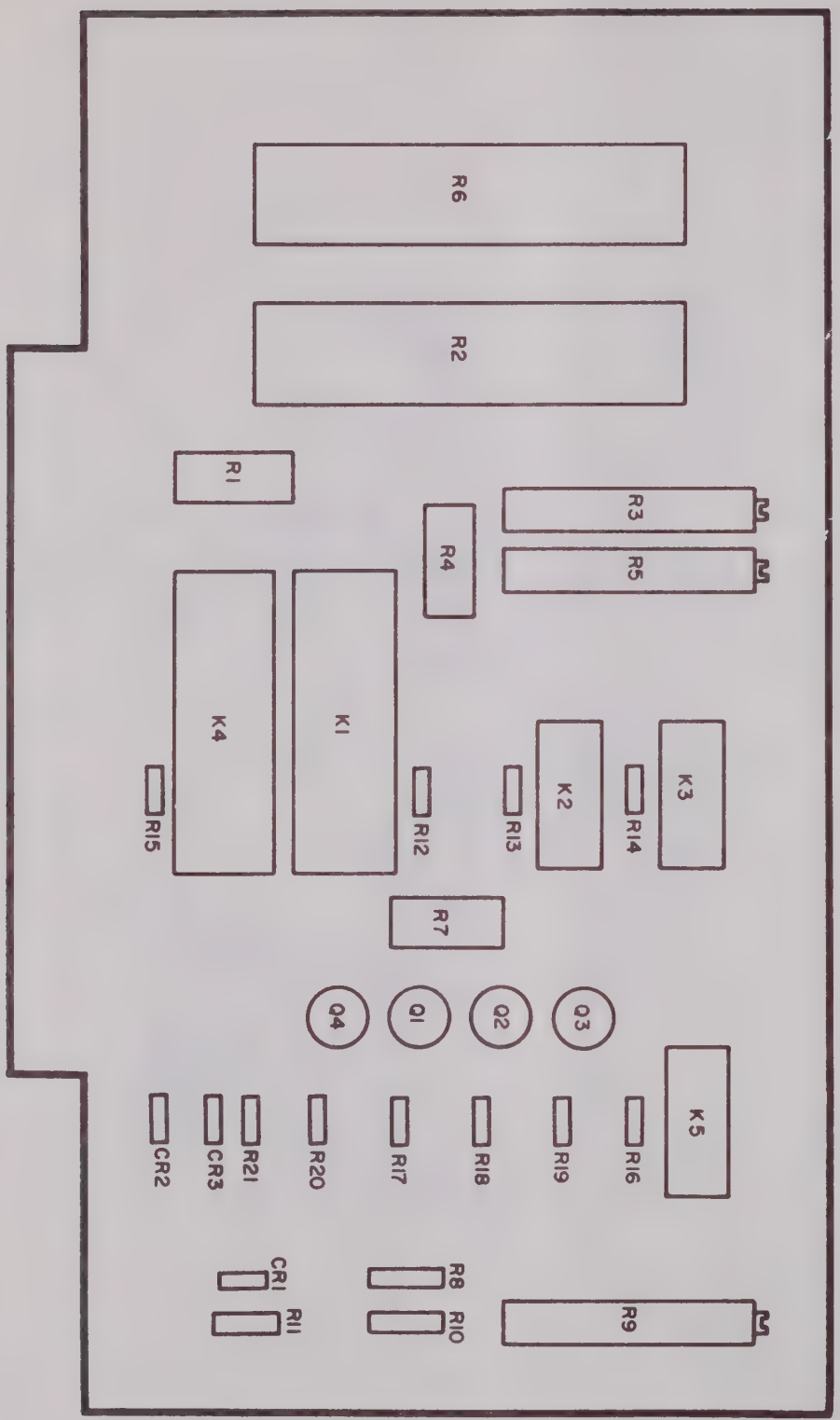


Figure 5-19. Component Location, DC Attenuator Assembly A8

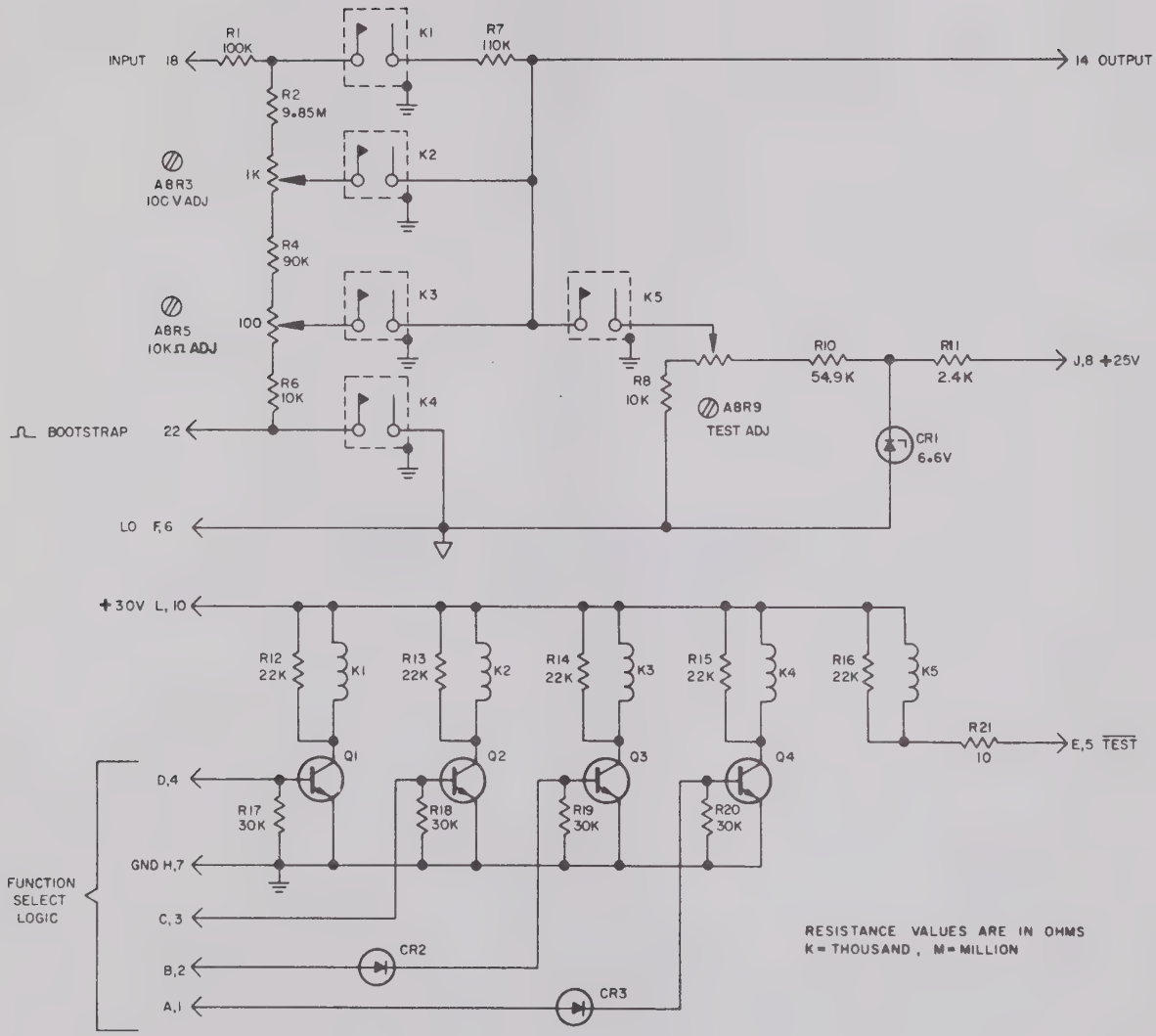


Figure 5-20. Schematic Diagram, DC Attenuator Assembly A8

Component Location, AC to DC Converter A9
not available at present.

Figure 5-21. Component Location, AC to DC Converter Assembly A9

Schematic Diagram, AC to DC Converter A9
not available at present.

Figure 5-22. Schematic Diagram, AC to DC Converter Assembly A9

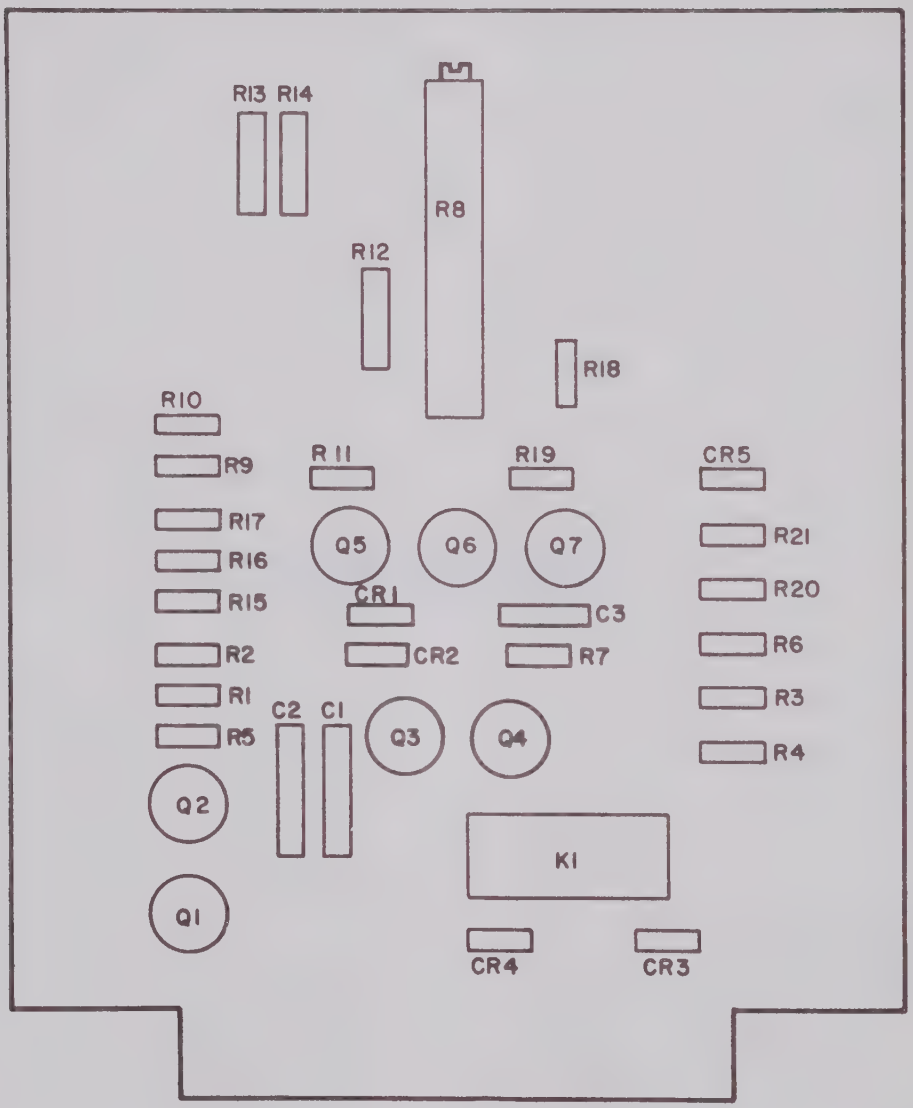


Figure 5-23. Component Location, Ohms Converter Assembly A10

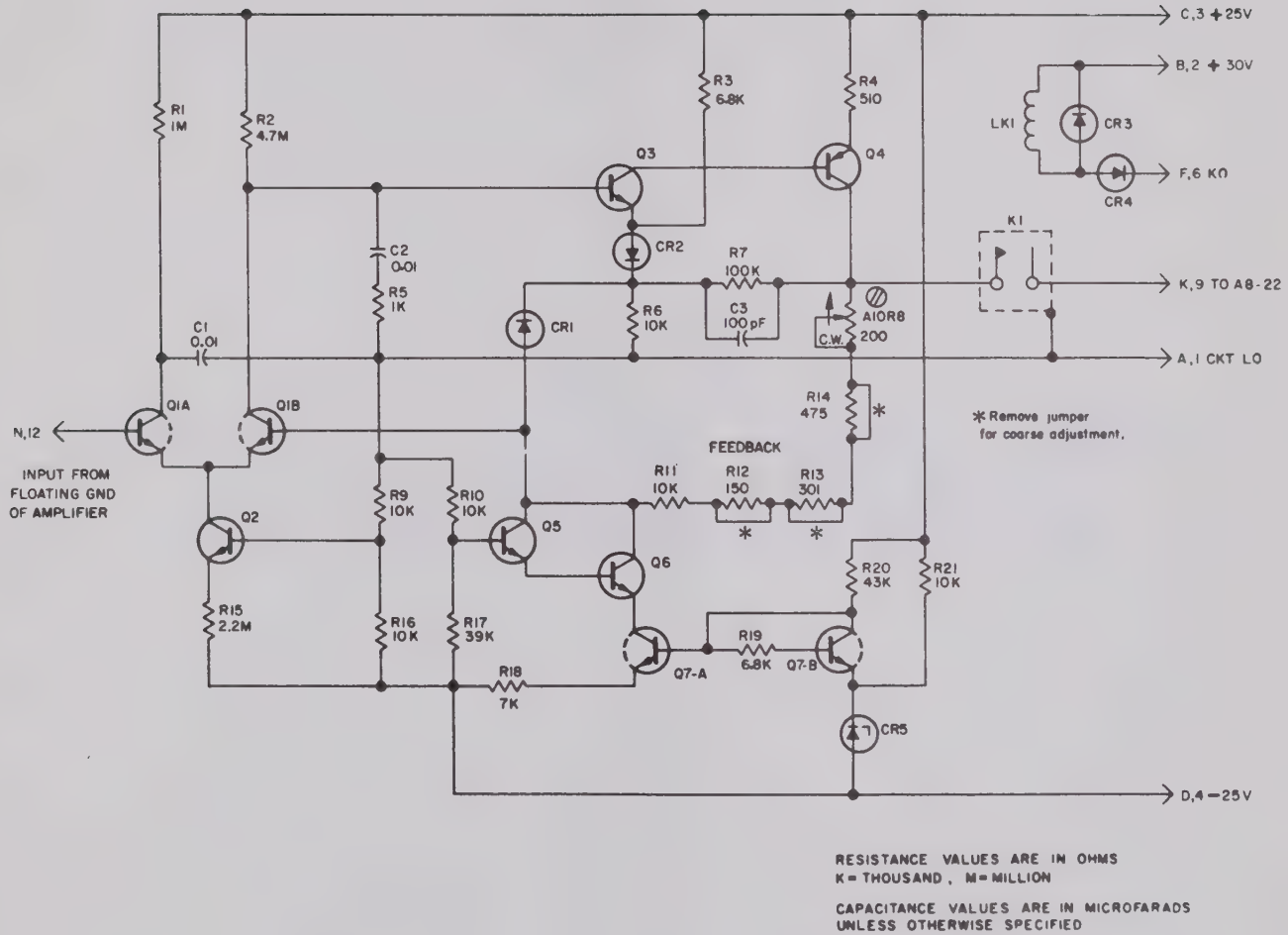


Figure 5-24. Schematic Diagram, Ohms Converter Assembly A10

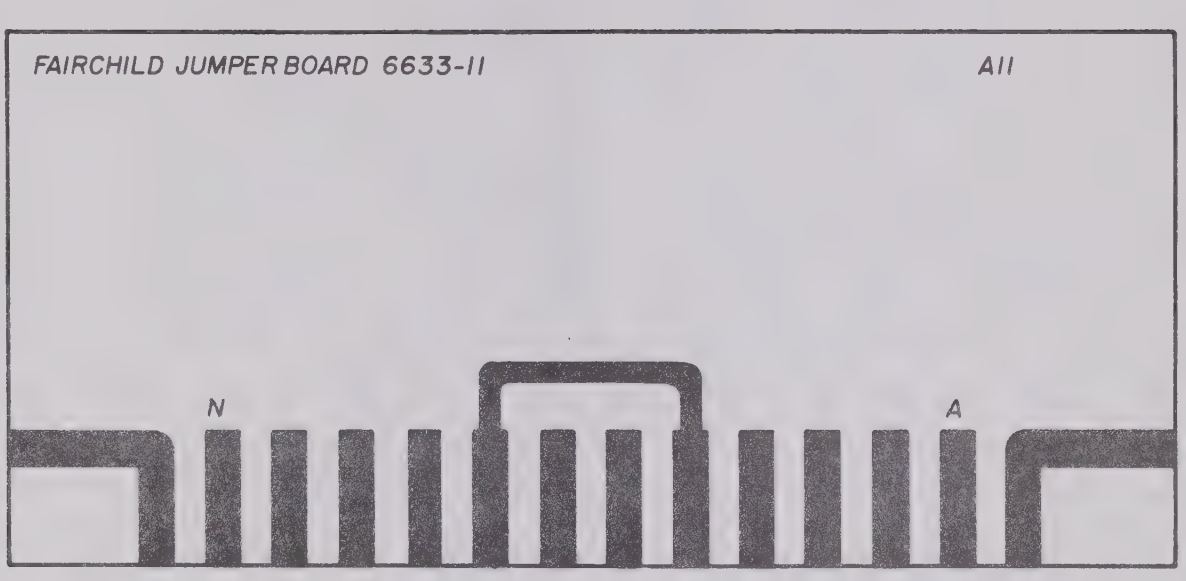


Figure 5-25. Jumper Board, Assembly A11

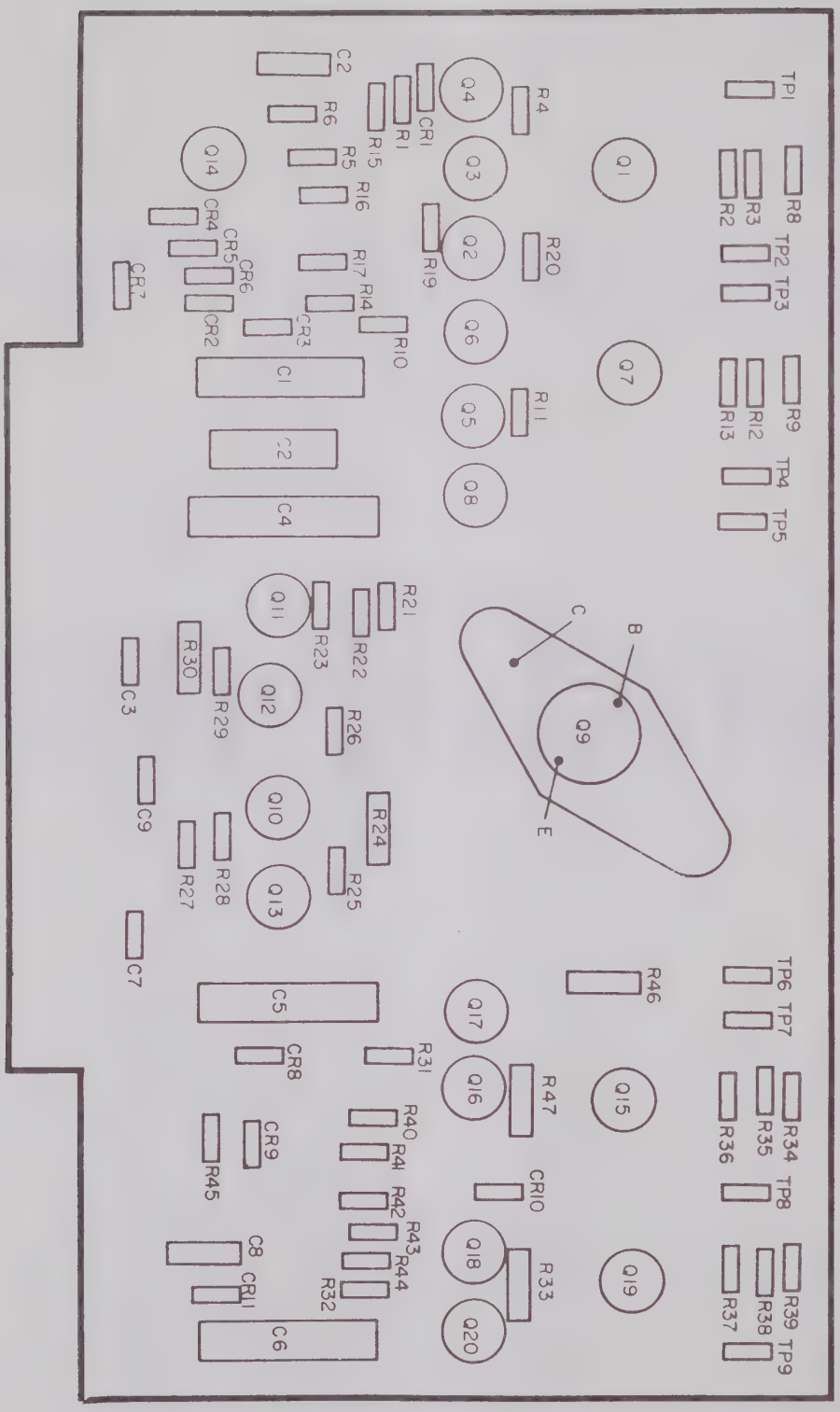
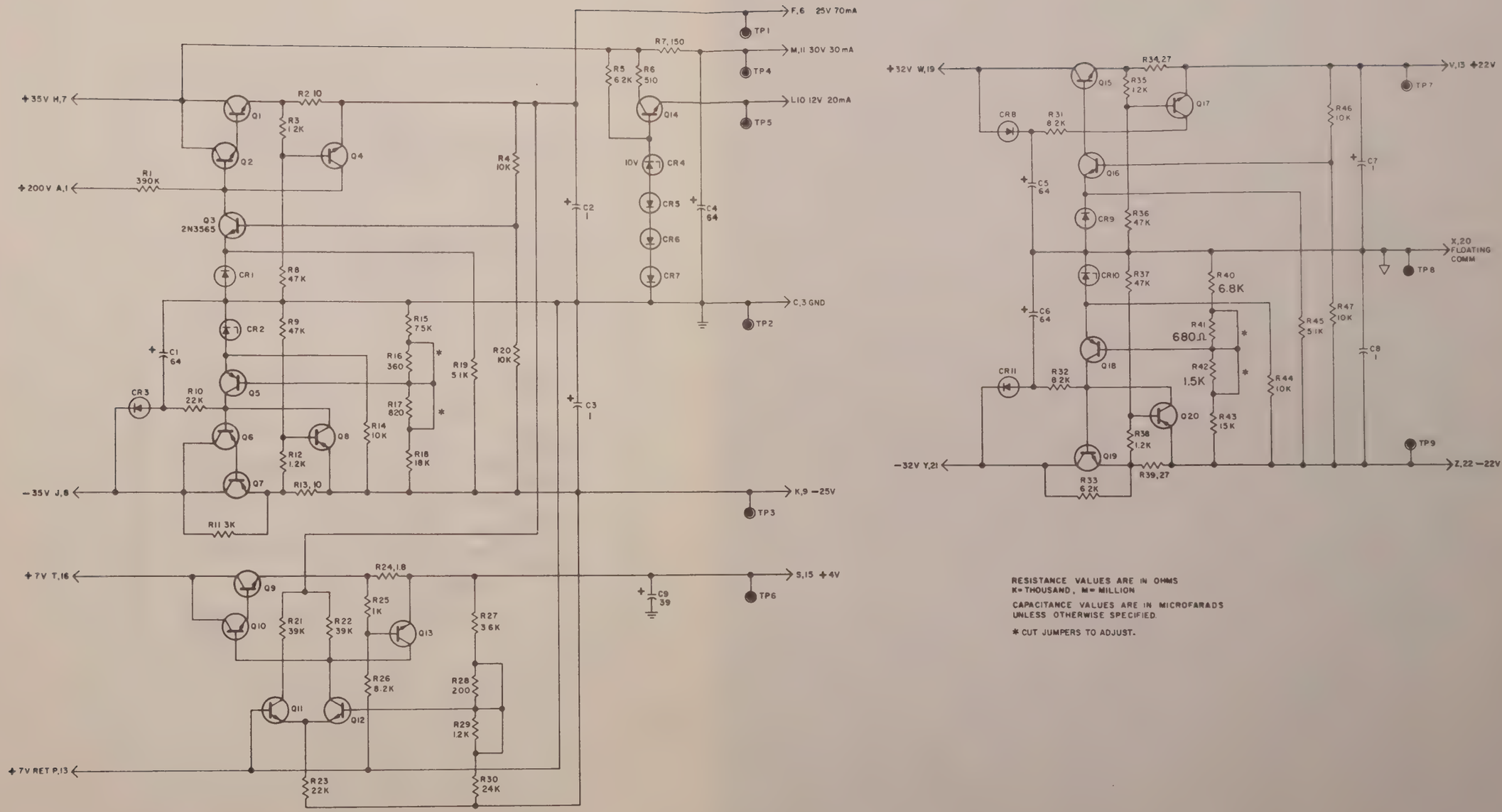


Figure 5-26. Component Location, Power Supplies Assembly A12



RESISTANCE VALUES ARE IN OHMS
K= THOUSAND, M= MILLION

CAPACITANCE VALUES ARE IN MICROFARADS
UNLESS OTHERWISE SPECIFIED.

* CUT JUMPERS TO ADJUST.

Figure 5-27. Schematic Diagram, Power Supplies Assembly A12

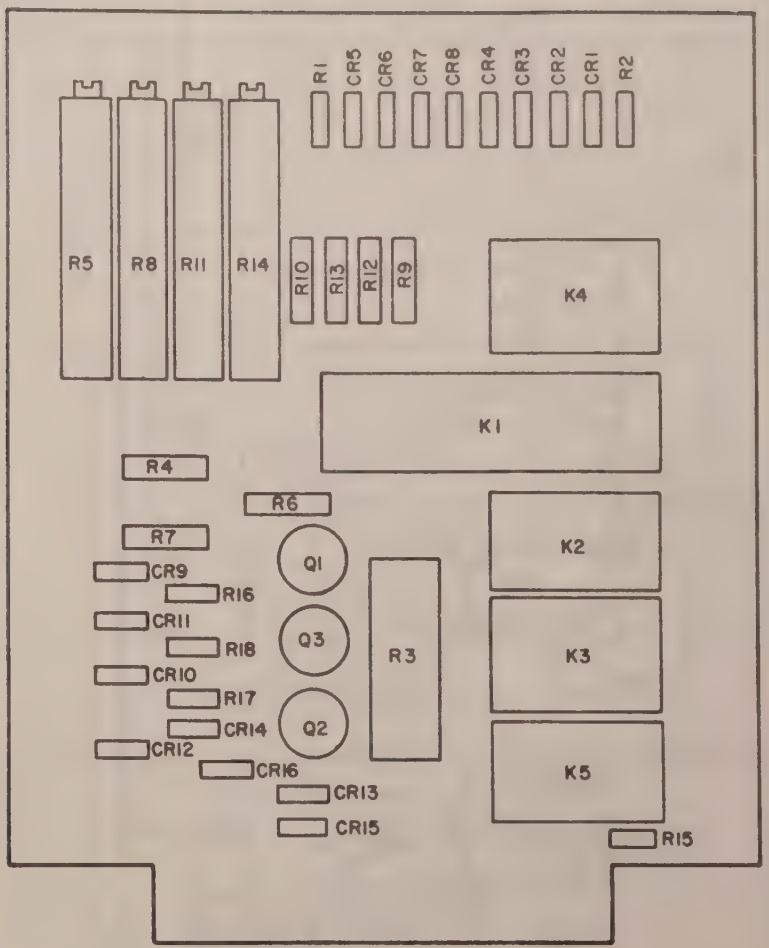


Figure 5-28. Component Location, Current Shunts Assembly A14

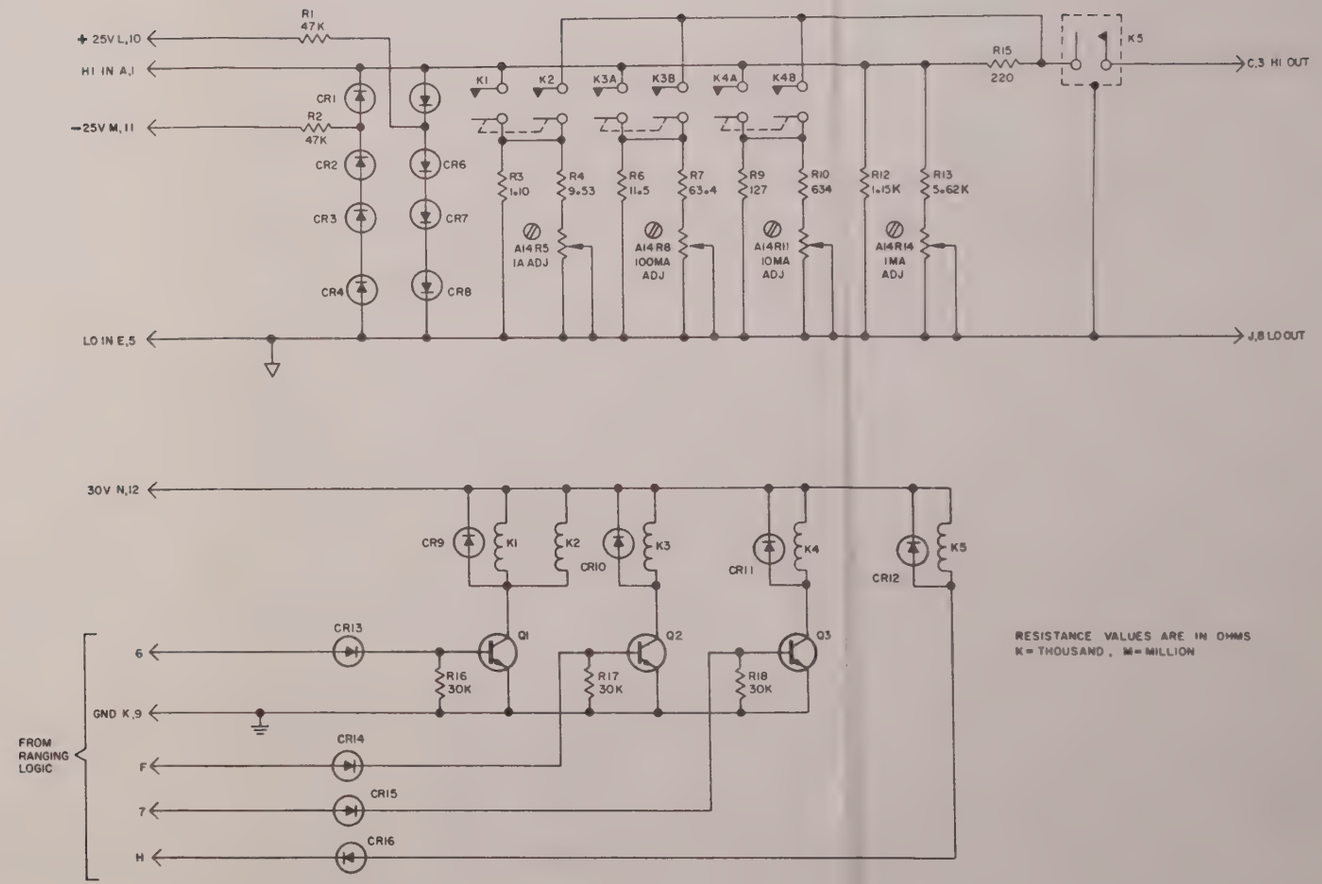


Figure 5-29. Schematic Diagram, Current Shunts Assembly A14

SECTION VI

REPLACEMENT PARTS

6-1. GENERAL

6-2. Tables 6-1 through 6-15 contain information for ordering replacement parts and list: circuit reference, description, manufacturer, and Fairchild Instrumentation part number. Physical location of electrical components and mechanical items are called out in section V and are cross-referenced with the parts list through the circuit reference numbers.

6-3. ORDERING INFORMATION

6-4. To order a replacement part, address the order to an authorized Fairchild Instrumentation sales representative, or to: 475 Ellis Street, Mountain View, California.

6-5. Specify the following for each part:

a. Model and serial number of instrument.

b. Fairchild Instrumentation part number.

c. Circuit reference designation, assembly number, or complete description.

6-6. To order a part not listed in tables 6-1 through 6-15, provide a complete description of the part, including function and location.

ABBREVIATIONS

AB	Allen-Bradley Co
Alco	Alco Electronic Prods. Inc.
Amperex	Amperex Electric Corp.
Beckman	Beckman Instruments Inc.
Carter	Carter Mfg. Corp.
CTS	Chicago Telephone Supply
Cinch	Cinch Mfg. Co.
Coto-Coil	Coto-Coil Co. Inc.
CGW	Corning Glass Works
Dale	Dale Electronics Corp.
Dialco	Dialight Corp.
Elmenco	The Electro Motive Mfg. Co.
Elpac	Elpac Capacitors
Fansteel	Fansteel Metallurgical Corp.
F.I.	Fairchild Instrumentation
F.S.	Fairchild Semiconductor
Gordos	Gordos Corp.
Grayhill	Grayhill, Inc.
HH Smith	Smith Inc.
IBM	International Business Machines
IRC	International Resistance Co.
JFD	JFD Electronic Corp.
Milton-Ross	Milton-Ross
Motorola	Motorola Semiconductor Prods.
Muter	The Muter Co.
NE	National Electronics
Raytheon	Raytheon Components Div.
Sangamo	Sangamo Electric Co.
Sprague	Sprague Electric Co.
TRW	TRW Capacitor Div.
Tower	Tower Mfg. Corp.
Viking	Viking Ind.
Vishay	Vishay Inst. Inc.
West Cap	San Fernando Electric

Table 6-1. Model 7000 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
A1	Assembly, Readout Board	FI	93000115
A2	Assembly, Counter	FI	93000201
A3	Assembly, BCD	FI	93000183
A4	Assembly, Auto Range	FI	93000184
A5	Assembly, Function Logic	FI	93000105
A6	Assembly, A-D Converter	FI	93000106
A7	Assembly, Input Amplifier	FI	93000107
A8	Assembly, DC Attenuator	FI	93000108
A9	Assembly, AC Converter	FI	93000189
A10	Assembly, Ohms Converter	FI	93000190
A11	Assembly, Jumper Board	FI	40036741
A12	Assembly, Power Regulator Board	FI	93000112
A13	Assembly, Mother Board	FI	93000113
A14	Assembly, Current Shunts	FI	93000194
DS1	Lamp, Cartridge, red	Dialco	12013740
F1	Fuse, 1/2 A		5700-03
J1	Connector, AC	Tower	6124-47
S1	Switch, slide 115 v/230 v	Muter	5602-09
S2	Switch, toggle, SPDT	Alco	5604-66
S3	Switch, Rotary 1 pol., 6 pos.	CTS	05019251
S4	Switch, Rotary 2 pol., 5 pos.	CTS	05019241
T1	Transformer (pre-wired)		93000142
TP1	Binding post, red	Grayhill	51017810
TP2	Binding post, black	Grayhill	51027800
TP3	Binding post, white	Grayhill	51023860
V1	Tube, readout, polarity	NE	5102-95
V2	Tube, readout	NE	5102-94
V3	Same as V2		
V4	Same as V2		

Table 6-1. Model 7000 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
V5	Same as V2		
V6	Same as V2		
XF1	Fuseholder		5700-31
	Miscellaneous - Main Assembly		
	Adapter, rear	FI	35079001
	Bail, Tilt		35071973
	Bezel, front	FI	C813465-03
	Bracket, Mother Board LH		6510-61
	Bracket, Mother Board RH		6510-62
	Cord, Power		5911-18
	Cover, Top	FI	6510-70
	Cover, Bottom	FI	6510-71
	Foot, instrument	FI	6500-41
	Guide, card		6206-89
	Guide, card		64018370
	Handle, strap		46018611
	Knob (2)	Raytheon	6204-79
	Nut, anchor		36011680
	Nut, Keps 6-32		3425-25
	Nut, Self Lock 6-32		3429-33
	Rails, side		35078051
	Screw, Black 6-32 x 1/4		60516010
	Screw, FH SS Black 8-32 x 7/8		3406-67
	Screw, Ph CR 6-32 x 3/8		3407-41
	Screw, Ph CR 6-32 x 5/16		3407-27
	Screw, Ph CR Black 6-32 x 5/16		60516000
	Screw, FH CR 6-32 x 1/8		60112540
	Screw, PH CR 4-40 x 3/4		3407-66
	Screw, FH CR 4-40 x 3/8		3411-34
	Strap, handle	FI	C812466-02
	Miscellaneous - Front Panel		
	Bezel, readout		64018581
	Fastener, clip-on		36011690
	Filter, readout		6511-70
	Nut, Keps 6-32		3425-25
	Screw, FH CR 6-32 x 5/16		3425-25

Table 6-1. Model 7000 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
	Miscellaneous - Rear Panel		
	Cover conn.		6510-66
	Nut, self lock 8-32		3429-35
	Screw, Ph CR 8/32 x 3/8		3407-65
	Screw, Ph CR 4-40 x 3/8		3407-68
	Washer, flat #8		
	Miscellaneous - Readout Assembly		
	Bracket, Readout Tubes		6510-65
	Grommet, 3/16" I.D. 5/16" Hole	HH Smith	6204-18
	Screw, PH CR 4-40 x 1/4		3407-69
	Washer Lock 4		3410-02

Table 6-2. Readout A1 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
R1	Resistor, fixed, 20k ±5%, 1/2 W	Amperex	02393221
R2	Same as R1		
R3	Same as R1		
R4	Same as R1		
R5	Same as R1		
R6	Same as R1		
XV1	Socket, tube, RTS-18	NE	5102-92
XV2	Same as XV1		
XV3	Same as XV1		
XV4	Same as XV1		
XV5	Same as XV1		
XV6	Same as XV1		

Table 6-3. Counter A2 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .01 μF, 200 V	Sprague	5300-28
C2	Capacitor, fixed, 6.8 μF, 6 V, 20%	Sprague	5304-80
C3	Capacitor, fixed, 680 pF	Elmenco	5300-89
C4	Capacitor, fixed, .1 μF, 200 V	TRW	5302-16
CR1	Diode, FD100	FS	26006930
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Diode, FD319	FS	26014520
CR7	Same as CR6		
Q1	Transistor, 2N720A	FS	5152-35
Q2	Same as Q1		
Q3	Transistor, 2N3693	FS	
Q4	Same as Q1		
Q5	Transistor, 2N3563		5154-96
Q6	Same as Q3		
Q7	Same as Q1		
Q8	Same as Q1		
Q9	Same as Q1		
Q10	Same as Q1		
Q11	Same as Q1		
Q12	Same as Q1		
QA1	Micrologic, element, 914	FS	5152-58
QA2	Micrologic, element, 974	FS	26012480
QA3	Same as QA1		
QA4	Micrologic, element, 960	FS	5155-27
QA5	Same as QA4		
QA6	Same as QA4		
QA7	Same as QA4		
QA8	Micrologic, element, 959	FS	5155-28
QA9	Same as QA8		

Table 6-3. Counter A2 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
QA10	Same as QA8		
QA11	Same as QA8		
QA12	Micrologic, element, 958	FS	5155-29
QA13	Same as QA12		
QA14	Same as QA12		
QA15	Same as QA12		
QA16	Same as QA1		
QA17	Same as QA2		
QA18	Same as QA2		
R1 through R6	Not assigned		
R7	Resistor, fixed, 4.7 M ±5%, 1/4 W	Amperex	5231-47
R8	Resistor, fixed, 270 k ±5%, 1/4 W	Amperex	5231-17
R9	Same as R8		
R10	Resistor, fixed, 1 M ±5%, 1/4 W	Amperex	5231-31
R11	Resistor, fixed, 1.5 M ±5%, 1/4 W	Amperex	5231-35
R12	Resistor, fixed, 10 k ±5%, 1/4 W	Amperex	02040721
R13	Same as R12		
R14	Resistor, fixed, 30 k ±5%, 1/4 W	Amperex	02040831
R15	Same as R8		
R16	Same as R14		
R17	Resistor, fixed, 2.2 k ±5%, 1/4 W	Amperex	02040561
R18	Same as R17		
R19	Same as R17		
R20	Same as R17		
R21	Resistor, fixed, 100 Ω ±5%, 1/4 W	Amperex	02040241
R22	Same as R14		
R23	Same as R14		
R24	Resistor, fixed, 6.8 k ±5%, 1/4 W	Amperex	
R25	Same as R17		
R26	Same as R17		
R27	Same as R21		

Table 6-3. Counter A2 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R28	Same as R14		
R29	Same as R14		
R30	Same as R21		
R31	Same as R14		
R32	Same as R14		
R33	Same as R21		
R34	Same as R14		
R35	Same as R14		
R36	Resistor, fixed, 4.7 k ±5%, 1/4 W	Amperex	02040641
R37	Same as R14		
R38	Same as R14		
R39	Same as R36		
R40	Resistor, fixed, 75 k, 1/4 W	Amperex	02040931
R41	Same as R40		
R42	Same as R40		
R43	Same as R40		
R44	Same as R8		
R45	Same as R8		
R46	Same as R8		
R47	Same as R8		
R48	Resistor, fixed, 10 Ω ±5%, 1/4 W	Amperex	02040001
XA1	Connector, 56 pin	Viking	6123-86

Table 6-4. BCD Converter Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
	The parts list of this option is not available at present.		

Table 6-5. Auto Range A4 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 6.8 μF 6V, 20%	Sprague	5304-80
C2	Capacitor, fixed, 0.1 μF, 200 V, 20%	West Cap	5304-81
C3	Same as C2		
C4	Capacitor, fixed, 0.0022 μF, 100 V, 5%	West Cap	03284750
C5	Capacitor, fixed, 0.01 μF, 200 V, 20%	West Cap	5304-83
C6	Same as C5		
C7	Same as C5		
C8	Same as C5		
C9	Same as C5		
C10	Same as C5		
C11	Same as C5		
C12	Same as C5		
CR1	Diode, FD100	FS	5151-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
CR10	Same as CR1		
CR11	Same as CR1		
CR12	Same as CR1		
CR13	Same as CR1		
CR14	Same as CR1		
CR15	Same as CR1		
CR16	Same as CR1		
CR17	Same as CR1		
CR18	Same as CR1		
CR19	Same as CR1		
CR20	Same as CR1		

Table 6-5. Auto Range A4 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
CR21	Same as CR1		
CR22	Same as CR1		
CR23	Same as CR1		
CR24	Diode, FD319 0	FS	26014520
CR25	Same as CR1		
CR26	Same as CR1		
CR27	Same as CR1		
CR28	Same as CR1		
CR29	Same as CR1		
CR30	Same as CR1		
CR31	Same as CR1		
CR32	Same as CR1		
CR33	Same as CR1		
CR34	Same as CR1		
CR35	Same as CR1		
CR36	Same as CR1		
CR37	Same as CR1		
Q1	Transistor, 2N3563	FS	5154-96
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
Q5	Same as Q1		
Q6	Same as Q1		
Q7	Same as Q1		
Q8	Same as Q1		
Q9	Same as Q1		
Q10	Same as Q1		
Q11	Same as Q1		
Q12	Same as Q1		
QA1	Micrologic, element, 910	FS	5152-82
QA2	Same as QA1		
QA3	Micrologic, element, 974	FS	5755-26

Table 6-5. Auto Range A4 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
QA4	Micrologic, element, 911	FS	5154-80
QA5	Same as QA4		
QA6	Same as QA1		
QA7	Same as QA4		
R1	Resistor, fixed, 4.7k ±5%, 1/4W	Amperex	02040641
R2	Resistor, fixed, 2.2k ±5%, 1/4 W	Amperex	02040561
R3	Same as R2		
R4	Same as R2		
R5	Same as R2		
R6	Same as R1		
R7	Same as R2		
R8	Resistor, fixed, 10k ±5%, 1/4W	Amperex	02040721
R9	Same as R1		
R10	Resistor, fixed, 22k ±5%, 1/4 W	Amperex	02040801
R11	Same as R2		
R12	Same as R2		
R13	Same as R2		
R14	Resistor, fixed, 36k ±5%, 1/4 W	Amperex	02040851
R15	Same as R14		
R16	Same as R14		
R17	Same as R14		
R18	Resistor, fixed, 3k ±5%, 1/4 W	Amperex	02040591
R19	Same as R18		
R20	Same as R18		
R21	Same as R18		
R22	Same as R18		
R23	Same as R18		
R24	Same as R10		
R25	Same as R10		
R26	Same as R10		
R27	Same as R10		
R28	Same as R10		
R29	Resistor, fixed, 30k ±5%, 1/4 W	Amperex	02040831

Table 6-5. Auto Range A4 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R30	Same as R29		
R31	Same as R29		
R32	Same as R29		
R33	Same as R29		
R34	Same as R14		
R35	Same as R14		
R36	Same as R14		
R37	Same as R14		

Table 6-6. Function Logic A5 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
CR1	Diode, FD3197O	FS	26014620
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Diode, FD100	FS	5151-37
CR6 through CR30	Same as CR5		
Q1	Transistor, fixed, 2N3563	FS	5154-96
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
R1	Resistor, fixed, 6.8 k ±5%, 1/4 W	Amperex	
R2	Same as R1		
R3	Same as R1		
R4	Same as R1		
R5	Resistor, fixed, 30 k ±5%, 1/4 W	Amperex	
R6	Same as R5		
R7	Same as R5		
R8	Same as R5		
R9	Resistor, fixed, 2.2k ±5%, 1/4W	Amperex	02040561
R10	Same as R9		
~~R11~~	~~Same as R9~~		
R12	Same as R9		
R13	Same as R9		
R14	Resistor, fixed, 4.7 k ±5%, 1/4 W	Amperex	02040641
R15	Same as R14		
R16	Same as R14		
R17	Same as R14		
R18	Same as R14		
R19	Same as R14		
R20	Same as R14		

Table 6-6. Function Logic A5 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R21	Same as R14		
R22	Same as R14		
R23	Same as R14		
R24	Same as R14		
R25	Same as R14		
R26	Same as R14		
R27	Same as R14		
R28	Same as R14		
R29	Same as R14		
R30	Same as R14		
R31	Same as R14		
R32	Same as R14		
R33	Same as R14		
R34	Same as R14		
R35	Same as R14		
R36	Same as R14		
R37	Same as R14		
R38	Resistor, fixed, 470 Ω ±5%, 1/4 W	Amperex	02040401
R39	Same as R38		
R40	Same as R38		
R41	Same as R38		
R42	Same as R38		

Table 6-7. A-D Converter A6 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 0.0068 μF, 100 V, 10%	TRW	5302-06
C2	Capacitor, fixed, 560 pF 300 V, 5%	Elmenco	5300-87
C3	Capacitor, fixed, 68 pF 300 V, 5%	Elmenco	5300-63
C4	Capacitor, fixed, 150 pF 300 V, 5%	Elmenco	5300-71
C5	Capacitor, fixed, 4 μF 100 V, 20%	TRW	5304-42
C6	Same as C5		
C7	Capacitor, fixed, 360 pF, 300 V, 5%	Elmenco	5300-81
C8	Same as C7		
C9	Capacitor, fixed, 0.01 μF, 200 V, 10%	TRW	5302-08
C10	Capacitor, fixed, 0.001 μF 100 V, 10%	TRW	5302-09
C11	Same as C10		
C12	Capacitor, fixed, 1 μF, 35 V, 20%	Sprague	5303-02
C13	Same as C13		
CR1	Diode, 1N3595	FS	26012540
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Diode, FD100	FS	5151-37
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
CR10	Same as CR1		
CR11	Transistor, FCT1035	FS	5161-40
CR12	Diode, 1N754A	FS	
CR13	Same as CR4		
CR14	Same as CR4		
CR15	Diode, 1N753A	FS	5161-37
CR16	Same as CR4		
CR17	Same as CR4		
CR18	Same as CR4		
CR19	Same as CR4		
CR20	Same as CR4		

Table 6-7. A-D Converter A6 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
CR21	Same as CR4		
CR22	Same as CR4		
CR23	Same as CR4		
CR24	Same as CR4		
CR25	Same as CR4		
CR26	Diode, Diode. FD319	FS	26014520
CR27	Same as CR4		
Q1	Transistor, 2N2920	FS	5154-06
Q2	Transistor, 2N3565	FS	5155-39
Q3	Same as Q2		
Q4	Transistor, 2N4250	FS	5155-39
Q5	Same as Q2		
Q6	Same as Q2		
Q7	Transistor, 2N4917		26013260
Q8	Same as Q4		
Q9	Same as Q1		
Q10	Same as Q4		
Q11	Same as Q2		
Q12	Same as Q7		
Q13	Same as Q1		
Q14	Same as Q2		
Q15	Transistor, 2N3693	FS	
Q16	Transistor, 2N3563		5154-93
Q17	Same as Q15		
Q18	Same as Q2		
Q19	Same as Q2		
Q20	Same as Q2		
Q21	Same as Q4		
Q22	Same as Q15		
QA1	Micrologic, element, μL U8X99142XX	FS	5154-71
QA2	Same as QA1		

Table 6-7. A-D Converter A6 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R1	Resistor, fixed, 68 k ±5%, 1/4 W	CGW	
R2	Resistor, fixed, 1k ±5%, 1/4 W	Amperex	02040481
R3	Resistor, fixed, 15 k ±5%, 1/4 W	Amperex	02040761
R4	Resistor, fixed, 150 k ±2%, 1/4 W	CGW	5208-88
R5	Resistor, fixed, 68 k ±5%, 1/4 W	Amperex	02040921
R6	Resistor, fixed, 100k ±5%, 1/4 W	Amperex	02040961
R7	Resistor, fixed, 10 k ±5%, 1/4 W	Amperex	02040721
R8	Resistor, fixed, 24 k ±5%, 1/4 W	Amperex	02040821
R9	Resistor, fixed, 1M, ±1%, 1/2 W	IRC	02394780
R10	Resistor, fixed, 12k ±5%, 1/4 W	Amperex	02040741
R11	Same as R2		
R12	Resistor, variable, 100 Ω ±20%, 3/4 W	Beckman	5291-08
R13	Resistor, fixed, 470 Ω, ±5%, 1/4 W	Amperex	02040401
R14	Resistor, fixed, 6.8 k ±5%, 1/4 W	Amperex	02040681
R15	Same as R2		
R16	Same as R10		
R17	Same as R2		
R18	Same as R10		
R19	Resistor, fixed, 2 k ±5%, 1/4 W	Amperex	
R20	Same as R2		
R21	Same as R6		
R22	Resistor, fixed, 90.9 Ω ±1%, 1/8 W	IRC	5208-56
R23	Resistor, fixed, 182 Ω ±1%, 1/8 W	IRC	5208-58
R24	Resistor, fixed, 332 Ω ±1%, 1/2 W	IRC	5208-58
R25	Resistor, fixed, 6.27 k ±.1%, 1/4 W	Vishay	02391440
R26	Resistor, fixed, 3 k ±5%, 1/4 W	Amperex	02040591
R27	Resistor, fixed, 47 k ±5%, 1/4 W	Amperex	02040881
R28	Same as R7		
R29	Same as R5		
R30	Same as R7		
R31	Resistor, fixed, 2.2 k ±5%, 1/4 W	Amperex	02040561
R32	Same as R7		
R33	Resistor, fixed, 10 k ±.01%, 1/4 W	Vishay	5220-74

Table 6-7. A-D Converter A6 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R34	Same as R33		
R35	Resistor, fixed, 220 Ω ±5%, 1/4 W	Amperex	02040321
R36	Resistor, fixed, 4.7 k ±5%, 1/4 W	Amperex	02040641
R37	Resistor, fixed, 51 Ω ±5%, 1/4 W	Amperex	02040171
R38	Same as R14		
R39	Same as R7		
R40	Resistor, fixed, 470 k ±5%, 1/4 W	Amperex	5231-23
R41	Resistor, fixed, 10 k ±2%, 1/4 W	CGW	5208-89
R42	Same as R26		
R43	Resistor, fixed, 220 k ±5%, 1/4 W	Amperex	5231-15
R44	Resistor, variable, 20 k ±20%, 3/4 W	Beckman	5291-17
R45	Resistor, fixed, 249 k ±1%, 1/8 W	IRC	02394740
R46	Resistor, variable, 10 k ±20%, 3/4 W	Beckman	5291-12
R47	Same as R41		
R48	Same as R40		
R49	Resistor, fixed, 22 k ±5%, 1/4 W	Amperex	02040801
R50	Same as R3		
R51	Same as R5		
R52	Same as R14		
R53	Resistor, fixed, 33 k ±2%, 1/4 W	CGW	5208-90
R54	Resistor, fixed, 68 k ±2%, 1/4 W	CGW	5208-91
R55	Same as R10		
R56	Resistor, fixed, 62 k ±5%, 1/4 W	Amperex	02040911
R57	Resistor, fixed, 1 M ±5%, 1/4 W	Amperex	5231-31
R58	Same as R7		
R59	Same as R36		
R60	Same as R5		
R61	Same as R36		
R62	Same as R56		
R63	Same as R7		
R64	Same as R36		
R65	Same as R14		
R66	Same as R7		

Table 6-7. A-D Converter A6 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R67	Resistor, fixed, 100 Ω ±5%, 1/4 W	Amperex	02040241
R68	Resistor, fixed, 30 k ±5%, 1/4 W	Amperex	02040831
R69	Same as R27		
R70	Same as R13		
R71	Same as R13		
R72	Same as R43		
R73	Same as R10		
R74	Resistor, fixed, 3.9 k ±5%, 1/4 W	Amperex	02040621

Table 6-8. Input Amplifier A7 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 0.22 μF, 600 V	Elpac	03286700
C2	Capacitor, fixed, 0.1 μF, 100 V, 10%	TRW	03286680
C3	Capacitor, fixed, 50 pF, 300 V, 5%	Elmenco	5300-59
C4	Capacitor, fixed, 0.0022 μF, 100 V, 10%	TRW	03286690
C5	Capacitor, variable, 0.5 - 4.5 pF	JFD	03270200
C6	Capacitor, fixed, 10 μF, 20 V, 20%	Sprague	03279100
C7	Capacitor, fixed, 0.01 μF, 200 V, 10%	TRW	03278900
C8	Capacitor, fixed, 39 μF, 10 V, 20%	Sprague	5304-79
C9	Capacitor, fixed, 0.0022 μF, 200 V, 10%	TRW	03278860
C10	Capacitor, fixed, 0.022 μF, 200 V, 10%	TRW	03278930
C11	Capacitor, fixed, 0.1 μF, 200 V, 10%	TRW	03278960
C12	Same as C8		
C13	Same as C7		
C14	Capacitor, fixed, 150 pF 300 V, 5%	Elmenco	5300-71
C15	Capacitor, fixed, 360 pF, 300 V, 5%	Elmenco	03279440
C16	Capacitor, fixed, 47 pF, 300 V, 5%	Elmenco	5300-58
C17	Same as C7		
C18	Capacitor, fixed, 75 pF, 300 V, 5%	Elmenco	03281880
C19	Same as C18		
C20	Capacitor, fixed, 0.0047 μF, 200 V, 10%	TRW	03278880
C21	Same as C7		
C22	Capacitor, fixed, 300 pF, 300 V, 5%	Elmenco	5300-79
CR1	Diode, 1N965B, 15 V	FS	5161-36
CR2	Same as CR1		
CR3	Diode, FD300	FS	26012320
CR4	Same as CR3		
CR5	Same as CR3		
CR6	Same as CR3		
CR7	Same as CR3		
CR8	Same as CR3		
CR9	Diode, FD100	FS	26006930
CR10	Same as CR9		
CR11	Same as CR9		

Table 6-8. Input Amplifier A7 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
CR12	Same as CR9		
CR13	Same as CR9		
CR14	Transistor, 2N3690	FS	5155-18
CR15	Same as CR14		
K1	Coil, relay U32-P	Coto Coil	
K1	Switch, reed	IBM	5605-34
Q1	Transistor, 2N3690	FS	5155-18
Q2	Transistor, 2N4120	FS	5155-14
Q3	Transistor, 2N4250	FS	5155-39
Q4	Transistor, 2N3565	FS	5154-91
Q5	Same as Q3		
Q6	Same as Q3		
Q7	Transistor, 2N3568	FS	5155-32
Q8	Transistor, S17395	FS	26003741
Q9	Same as Q8		
Q10	Same as Q4		
Q11	Transistor, 2N4249	FS	26013260
Q12	Same as Q7		
Q13	Transistor, 2N1893	FS	26007250
Q14	Transistor, 2N3072	FS	26008560
Q15	Same as Q11		
Q16	Same as Q4		
Q17	Same as Q4		
Q18	Same as Q4		
Q19	Not assigned		
Q20	Not assigned		
Q21	Same as Q8		
Q22	Same as Q8		
R1	Resistor, fixed, 6.8 k ±5%, 1/4 W	Amperex	02040681
R2	Same as R1		
R3	Resistor, fixed, 100 k ±5%, 1/4 W	Amperex	02040961
R4	Resistor, fixed, 220 k ±5%, 2 W	AB	02037040
R5	Resistor, fixed, 10 k ±5%, 1/4 W	Amperex	02040721

Table 6-8. Input Amplifier A7 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R6	Resistor, fixed, 1 k ±5%, 1/4 W	Amperex	02040481
R7	Same as R6		
R8	Resistor, fixed, 30 k ±5%, 1/4 W	Amperex	02040831
R9	Same as R3		
R10	Resistor, fixed, 120 k ±5%, 1/4 W	Amperex	02040981
R11	Same as R10		
R12	Resistor, fixed, 33 k ±5%, 1/4 W	Amperex	02040841
R13	Resistor, fixed, 200 k ±5%, 1/4 W	Amperex	02041031
R14	Same as R3		
R15	Same as R3		
R16	Resistor, fixed, 2.2 M ±5%, 1/4 W	Amperex	02355410
R17	Same as R16		
R18	Same as R5		
R19	Resistor, fixed, 2.7 Ω ±5%, 1/4 W	Amperex	5230-00
R20	Resistor, fixed, 22 k ±5%, 1/4 W	Amperex	02040801
R21	Resistor, fixed, 47 k ±5%, 1/4 W	Amperex	02040881
R22	Same as R5		
R23	Resistor, fixed, 470 k ±5%, 1/4 W	Amperex	02355250
R24	Same as R23		
R25	Same as R12		
R26	Same as R16		
R27	Resistor, fixed, 10 M ±5%, 1/4 W	Amperex	02355570
R28	Resistor, fixed, 620 k ±5%, 1/4 W	Amperex	02355280
R29	Resistor, fixed 360 k ±5%, 1/4 W	Amperex	02355220
R30	Same as R27		
R31	Resistor, fixed, 5.1 k ±5%, 1/4 W	Amperex	02040651
R32	Resistor, variable, 10 k ±20%, 3/4 W	Beckman	5291-12
R33	Same as R31		
R34	Resistor, fixed, 2 k ±5%, 1/4 W	Amperex	02040551
R35	Same as R31		
R36	Resistor, fixed, 470 Ω ±5%, 1/4 W	Amperex	02040411
R37	Resistor, fixed, 3.3 k ±5%, 1/4 W	Amperex	02040601
R38	Same as R3		

Table 6-8. Input Amplifier A7 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R39	Same as R5		
R40	Same as R31		
R41	Resistor, fixed, 220 Ω ±5%, 1/4 W	Amperex	02040321
R42	Same as R41		
R43	Same as R20		
R44	Same as R5		
R45	Same as R3		
R46	Same as R5		
R47	Same as R20		
R48	Same as R20		
R49	Same as R20		
R50	Same as R23		
R51	Same as R23		
R52	Same as R5		
R53	Resistor, fixed, 3.9 k ±5%, 1/4 W	Amperex	02040621
R54	Same as R53		
R55	Resistor, fixed, 1 k ±.01%, 1/4 W	Vishay	5220-70
R56	Resistor, fixed, 9 k ±.01%	Vishay	5220-69
R57	Resistor, fixed, 4.7 M ±5%, 1/2 W	Amperex	02031360
R58	Resistor, variable, 100 Ω ±20%, 3/4 W	Beckman	5291-08
	Miscellaneous		
	Transipad, TO-5	Milton-Ross	6249-80
	Coil, Relay U32-P		5602-81
	Reed, switch		05034670

Table 6-9. DC Attenuator A8 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
CR1	Diode, 1N827	FS	26013960
CR2	Diode, FD100	FS	26006930
CR3	Same as CR2		
K1	Switch, reed	Gordos	05034550
K2	Switch, reed	IBM	05034700
K3	Same as K2		
K4	Same as K1		
K5	Same as K2		
LK1	Coil, relay, SP24P	Coto-Coil	21103060
LK2	Coil, relay, U32P	Coto-Coil	5602-81
LK3	Same as LK2		
LK4	Same as LK1		
LK5	Same as LK2		
Q1	Transistor, 2N3694	FS	5155-18
Q2	Same as Q1		
Q3	Same as Q1		
Q4	Same as Q1		
R1	Resistor, fixed, 100 k ±5%, 1 W	AB	02033960
R2	Resistor, fixed, 9.85 M ±.25%, 2 W	IRC	5205-03
R3	Resistor, variable, 1 k	Beckman	5291-10
R4	Resistor, fixed, 90 k ±.25%, 1/2 W	IRC	5205-01
R5	Resistor, variable, 100 Ω	Beckman	5291-08
R6	Resistor, fixed, 10 k ±.25%, 2 W	IRC	5205-04
R7	Resistor, fixed, 110 k ±5%, 1 W	AB	02033920
R8	Resistor, fixed, 10 k ±.25%, 1/8 W	IRC	5205-05
R9	Resistor, variable, 2 k	Beckman	5291-11
R10	Resistor, fixed 54.9 k ±1%, 1/8 W	IRC	02374630
R11	Resistor, fixed, 2.4 k ±5%, 1/2 W	Amperex	02393001
R12	Resistor, fixed, 22 k ±5%, 1/4 W	Amperex	02040171
R13	Same as R12		
R14	Same as R12		
R15	Same as R12		
R16	Same as R12		

Table 6-9. DC Attenuator A8 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R17	Resistor, fixed, 30 k ±5%, 1/4 W	Amperex	02040831
R18	Same as R17		
R19	Same as R17		
R20	Same as R17		
R21	Resistor, fixed, 10 Ω ±5%, 1/4 W	Amperex	02040001
	Miscellaneous		
	Shield Relay Reed, small		6510-68
	Shield Relay Reed, large		6510-67

Table 6-10. AC to DC Converter A9 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
	The parts list of this option is not available at present.		

Table 6-11. Ohms Converter A10 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, .01 μF, 200 V	TRW	5302-08
C2	Same as C1		
C3	Capacitor, fixed, 100 pF	Elmenco	5300-67
CR1	Diode, FD100	FS	5151-37
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Diode, FD319 0	FS	26014520
CR5	Diode, 1N827	FS	26013960
K1	Switch, reed	IBM	5605-34
LK1	Coil, relay	Coto-Coil	5603-81
Q1	Transistor, 2N2920	FS	5154-06
Q2	Transistor, 2N3565	FS	5154-91
Q3	Same as Q2		
Q4	Transistor, 2N4250	FS	5155-39
Q5	Same as Q2		
Q6	Same as Q2		
Q7	Same as Q1		
R1	Resistor, fixed, 1 M ±5%, 1/4 W	Amperex	5231-41
R2	Resistor, fixed, 4.7 M ±5%, 1/4 W	Amperex	5231-47
R3	Resistor, fixed, 6.8 k ±5%, 1/4 W	Amperex	02040681
R4	Resistor, fixed, 510 Ω ±5%, 1/4 W	Amperex	02040411
R5	Resistor, fixed, 1 k ±5%, 1/4 W	Amperex	02040481
R6	Resistor, fixed, 10 k ±5%, 1/4 W	Amperex	02040721
R7	Resistor, fixed, 100 k ±5%, 1/4 W	Amperex	02040961
R8	Resistor, variable, 200 Ω ±20%, 3/4 W	Beckman	5291-09
R9	Same as R6		
R10	Same as R6		
R11	Resistor, fixed, 10 k ±.1%	Vishay	5220-71
R12	Resistor, fixed, 150 Ω ±1% (T-0)	IRC	02394760
R13	Resistor, fixed, 301 Ω ±1% (T-2)	IRC	02394770
R14	Resistor, fixed, 475 Ω ±1% (T-2)	IRC	02394750

Table 6-11. Ohms Converter A10 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R15	Resistor, fixed, 2.2 M ±5%, 1/4 W	Amperex	5231-39
R16	Same as R6		
R17	Resistor, fixed, 39 k ±5%, 1/4 W	Amperex	02040861
R18	Resistor, fixed, 6.5 k ±.1%		02403000
R19	Same as R3		
R20	Resistor, fixed, 43 k ±5%, 1/4 W	Amperex	02040871
R21	Resistor, fixed, 6.8 k ±5%, 1/2 W		02393001
	Shield, Relay Reed	F.I.	6510-68

Table 6-12. Jumper Board A11 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
	This board contains no components and is used when A14 (current shunts) is not used.		

Table 6-13. Power Regulator A12 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 64 μF 64 V	Amperex	5304-78
C2	Capacitor, fixed, 1 μF, 35 V	Fansteel	5303-02
C3	Same as C2		
C4	Same as C1		
C5	Same as C1		
C6	Same as C1		
C7	Same as C2		
C8	Same as C2		
C9	Capacitor, fixed, 39 μF, 10 V	Sprague	5304-79
CR1	Diode, FD100	FS	5151-37
CR2	Diode, 1N754A		5161-38
CR3	Diode, 1N4003	Motorola	5152-71
CR4	Diode, 1N758A, 10 V	FS	26012550
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR3		
CR9	Same as CR1		
CR10	Same as CR2		
CR11	Same as CR3		
Q1	Transistor, SE7005	FS	5155-37
Q2	Transistor, 2N3565	FS	5154-91
Q3	Same as Q2		
Q4	Transistor, 2N1893		5154-19
Q5	Transistor, 2N4250	FS	5155-39
Q6	Same as Q5		
Q7	Transistor, 2N3072	FS	5152-84
Q8	Same as Q5		
Q9	Transistor, SE3036	FS	5155-38
Q10	Same as Q2		
Q11	Same as Q2		
Q12	Same as Q2		
Q13	Same as Q2		
Q14	Transistor, 2N1894	FS	5151-90

Table 6-13. Power Regulator A12 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
Q15	Same as Q1		
Q16	Same as Q2		
Q17	Same as Q2		
Q18	Same as Q5		
Q19	Same as Q7		
Q20	Same as Q5		
R1	Resistor, fixed, 390 k ±5%, 1/4 W	Amperex	5231-21
R2	Resistor, fixed, 10 Ω ±5%, 1/4 W	Amperex	5230-11
R3	Resistor, fixed, 1.2 k ±5%, 1/4 W	Amperex	02040501
R4	Resistor, fixed, 10 k ±5%, 1/2 W	Amperex	02393150
R5	Resistor, fixed, 6.2 k ±5%, 1/4 W	Amperex	02040671
R6	Resistor, fixed, 510 Ω ±5%, 1/2 W	Amperex	02392840
R7	Resistor, fixed, 150 Ω ±5%, 2 W	AB	5240-17
R8	Resistor, fixed, 47 k ±5%, 1/4 W	Amperex	02040881
R9	Same as R8		
R10	Resistor, fixed, 22 k ±5%, 1/4 W	Amperex	02040801
R11	Resistor, fixed, 3 k ±5%, 1/2 W	Amperex	02393020
R12	Same as R3		
R13	Same as R2		
R14	Resistor, fixed, 10 k ±5%, 1/4 W	Amperex	02040721
R15	Resistor, fixed, 7.5 k ±5%, 1/2 W	Amperex	02393120
R16	Resistor, fixed, 360 Ω ±5%, 1/4 W	Amperex	02040371
R17	Resistor, fixed, 820 Ω ±5%, 1/4 W	Amperex	02040461
R18	Resistor, fixed, 18 k ±5%, 1/2 W	Amperex	02393210
R19	Resistor, fixed, 5.1 k ±5%, 1/4 W	Amperex	02040651
R20	Same as R4		
R21	Resistor, fixed, 39 k ±5%, 1/4 W	Amperex	02040861
R22	Same as R21		
R23	Same as R10		
R24	Resistor, fixed, 1.8 Ω ±5%, 1/2 W	Amperex	02412910
R25	Resistor, fixed, 1 k ±5%, 1/4 W	Amperex	02040481
R26	Resistor, fixed, 8.2 k ±5%, 1/4 W	Amperex	02040701
R27	Resistor, fixed, 3.6 k ±5%, 1/2 W	Amperex	02393140

Table 6-13. Power Regulator A12 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R28	Resistor, fixed, 200 Ω ±5%, 1/4 W	Amperex	02040311
R29	Same as R3		
R30	Resistor, fixed, 24 k ±5%, 1/2 W	Amperex	02392741
R31	Same as R26		
R32	Same as R26		
R33	Resistor, fixed, 6.2 k ±5%, 1/2 W	Amperex	02393100
R34	Same as R29		
R35	Same as R3		
R36	Same as R8		
R37	Same as R8		
R38	Same as R3		
R39	Same as R34		
R40	Resistor, fixed, 6.8 k ±2%, 1/4 W		02397580
R41	Resistor, fixed, 680 Ω ±5%, 1/4 W		02354580
R42	Resistor, fixed, 1.5 k ±5%, 1/4 W	Amperex	02354650
R43	Resistor, fixed, 15 k ±2%, 1/4 W	Amperex	02397660
R44	Same as R14		
R45	Same as R19		
R46	Same as R4		
R47	Same as R4		
TP1	Test Jack, P.C., red	Carter	6112-43
TP2	Test Jack, P.C., orange	Carter	09062530
TP3	Test Jack, P.C., green	Carter	6112-45
TP4	Test Jack, P.C. blue	Carter	6112-46
TP5	Test Jack, P.C. violet	Carter	6112-47
TP6	Test Jack, P.C. yellow	Carter	6112-44
TP7	Test Jack, P.C. white	Carter	09062590
TP8	Test Jack, P.C. brown	Carter	6112-42
TP9	Test Jack, P.C. black	Carter	6112-41
	Miscellaneous		
	Elastic Stop Nut		3429-34
	Screw, Pan Head, Cross Rec.		3407-61
	Pad, Transistor (3)		6249-80

Table 6-14. Mother Board A13 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 80 μF, 300 V	Sangamo	5304-76
C2	Capacitor, fixed, 2X650 μF, 50 V	Sangamo	03280190
C3	Same as C2		
C4	Capacitor, fixed, 2X1200 μF, 25 V	Sangamo	5304-74
C5	Same as C2		
C6	Same as C2		
CR1	Diode, 1N4005	Motorola	5161-26
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Same as CR1		
CR10	Same as CR1		
CR11	Same as CR1		
CR12	Same as CR1		
CR13	Same as CR1		
CR14	Same as CR1		
R1	Resistor, fixed, 100 k, ±5%, 1/2 W	Amperex	02393391
XA1	Not assigned		
XA2	Connector, 22 pin Dual	Cinch	6124-67
XA3	Same as XA2		
XA4	Connector, 12 pin Dual	Cinch	6124-69
XA5	Same as XA4		
XA6	Same as XA2		
XA7	Same as XA2		
XA8	Same as XA2		
XA9	Same as XA2		
XA10	Same as XA4		
XA11	Same as XA4		
XA12	Same as XA2		

Table 6-15. Current Shunts A14 Parts List

Circuit Reference	Description	Manufacturer	FI Part Number
CR1	Diode, 1N4003	Motorola	5152-71
CR2	Same as CR1		
CR3	Same as CR1		
CR4	Same as CR1		
CR5	Same as CR1		
CR6	Same as CR1		
CR7	Same as CR1		
CR8	Same as CR1		
CR9	Diode, FD100	FS	5151-37
CR10	Same as CR9		
CR11	Same as CR9		
CR12	Same as CR9		
CR13	Same as CR9		
CR14	Same as CR9		
CR15	Same as CR9		
CR16	Diode, 1N3070	FS	26012560
K1	Reed, switch	Gordos	5604-87
K2	Reed, switch	IBM	5605-34
K3A	Same as K2		
K3B	Same as K2		
K4A	Same as K2		
K4B	Same as K2		
K5	Same as K2		
LK1	Coil, relay, SD24P		21103060
LK2	Coil, relay, U32P		5602-81
LK3	Coil, relay, dual UD32P		21103070
LK4	Same as LK3		
LK5	Same as LK2		
Q1	Transistor, 2N3694	FS	5155-18
Q2	Same as Q1		
Q3	Same as Q1		

Table 6-15. Current Shunts A14 Parts List (Cont)

Circuit Reference	Description	Manufacturer	FI Part Number
R1	Resistor, fixed, 47 k ±5%, 1/4 W	Amperex	02040881
R2	Same as R1		
R3	Resistor, fixed, 1.10 Ω ±1%, 7 W	Dale	5218-42
R4	Resistor, fixed, 9.53 Ω ±1%	Dale	02393980
R5	Resistor, variable, 10 Ω	Beckman	5291-07
R6	Resistor, fixed, 11.5 Ω, ±1%	Dale	5208-55
R7	Resistor, fixed, 63.4 Ω	IRC	5208-58
R8	Resistor, variable, 100 Ω	Beckman	5291-08
R9	Resistor, fixed, 127 Ω ±1%	IRC	5208-57
R10	Resistor, fixed, 634 Ω ±1%	IRC	5208-61
R11	Resistor, variable 1 k	Beckman	5291-10
R12	Resistor, fixed, 1.15 k ±1%	IRC	5208-52
R13	Resistor, fixed, 5.62 ±1%	IRC	5208-50
R14	Resistor, variable, 10 k	Beckman	5291-12
R15	Resistor, fixed, 220 Ω ±5%, 1/4 W	Amperex	02040321
R16	Resistor, fixed, 30 k ±5%, 1/4 W	Amperex	02040831
R17	Same as R16		
R18	Same as R16		
	Miscellaneous		
	Shield, relay reed	FI	6510-68

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